CARBON SEQUESTRATION: RISKS, OPPORTUNITIES, AND PROTECTION OF DRINKING WATER

HEARING

BEFORE THE

SUBCOMMITTEE ON ENVIRONMENT AND HAZARDOUS MATERIALS

OF THE

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[1] Mr. Duncan did not answer submitted questions for the record.

CARBON SEQUESTRATION: RISKS, OPPORTUNITIES, AND PROTECTION OF DRINKING WATER

THURSDAY, JULY 24, 2008

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT AND HAZARDOUS MATERIALS,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 10:05 a.m., in Room 2322 of the Rayburn House Office Building, Hon. Gene Green (chairman) presiding.

Members present: Representatives Green, Solis, Baldwin, Butterfield, Barrow, Hill, Schakowsky, Matsui, Dingell (ex officio), Shadegg, Radanovich, Pitts, Terry, Murphy, and Barton (ex officio).

Staff present: Caroline Ahearn, Ben Hengst, Andrew Wallace, Chris Treanor, Rachel Bleshman, Katherine Brittain, Michelle Byrne, Alex Haurek, David McCarthy, Jerry Couri, Amanda Mertens Campbell, Andrea Spring, and Garrett Golding.

OPENING STATEMENT OF HON. GENE GREEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Mr. GREEN. I call this meeting to order, and today we have a hearing entitled "Carbon Sequestration: Risks, Opportunities and Protection of Drinking Water." For purposes of making opening statements, the Chair and the ranking members of the subcommittee and the full committee will each be recognized for 5 minutes. All other members of the subcommittee will be recognized for 3 minutes. Those members may waive the right to make an opening statement and when first recognized to question witnesses, instead add 3 minutes to their time for questions. Without objections, all members have five legislative days to submit their opening statement. And I will recognize myself for my opening statement.

Now, first I want to state that I am glad to be here in the first hearing of the subcommittee in my capacity as Chair. I intend the subcommittee be active and engaged with its jurisdiction and operate in a conclusive fashion for the benefit of all its members. Former Chairman Al Wynn is a good friend and did an excellent job and I am grateful to vice chair Hilda Solis of California, for her active role on the subcommittee. I am also looking forward to working with our ranking member, Mr. Shadegg of Arizona, and all our members. And I will welcome the ranking member.

Today's hearing is timely, given the recent released EPA proposal for regulating carbon sequestration. EPA's proposal seeks to provide regulatory certainty for potential sequestration projects which would be an important foundation for any future climate change legislation.

Our subcommittee intends to work diligently on the oversight of this rulemaking and examine whether EPA requires additional authority to regulate underground carbon sequestration.

Carbon capture and sequestration is known as CCS. It is one of the most important possible solutions for climate change. Without sequestration, coal fire power plants could go from being a low cost option to a high cost option if Congress regulates greenhouse gas emissions. Electricity, heating, and manufacturing costs could rise economy wide, at least, in the short and medium term.

Cost models for climate change legislation are highly dependent on the development of future technologies which are inherently difficult to predict. Several models do tell us, however, that one of the largest variables for the impact of cost—energy cost, is the availability of CCS. EPA's analysis of the recent Lieberman-Werner bill indicates that CCS could account for 30 percent of the CO_2 reductions by 2015, which would involve injecting many gigatons of CO_2 underground. If CCS were unavailable, these reductions would have to come from elsewhere and, likely, at a higher cost. CCS has two major components, capture and sequestration. To date much of the attention has been on capture. Last week our Energy and Air Quality Subcommittee held a hearing on the important legislation introduced by Chairman Boucher to move capture technology into the commercial phase. We are holding our hearing to inform Congress of the geological opportunities to sequester carbon and potential risk of underground injection of CO_2 on a massive scale.

Unlike capture, carbon injection technology is well established and has been used for enhanced oil recovery for over 30 years. The Permian Basin in west Texas is home to the majority of carbon dioxide injection and the majority of the carbon dioxide injection in the entire world. This is good news for addressing climate change and producing more domestic energy.

Carbon sequestration differs from enhanced oil recovery in two ways. The volumes of CO_2 for sequestration are much larger and long-term storage must make sure that CO_2 does not come back up. Large scale CO_2 sequestration could have a number of unintended consequences underground, if done improperly. The injected CO_2 will contain pollutants such as sulfur or mercury from power plant emissions, or it could cause heavy metals underground to leach into ground water. If injected near fault lines, the pressure could cause seismic activity, which could allow CO_2 to escape. CO_2 would push saline aquifiers into fresh water occupiers, harming drinking water and otherwise alter ground water. The EPA's proposed sequestration rule creates a new class of regulated well for the underwater injection control, the UIC program, which operates under the Safe Water Drinking Act. The Act provides minimum standards for protecting underground sources of drinking water and our committee needs to know whether that authority is sufficient to address the leaks of CO_2 back in the atmosphere or other risks.

The proposed rule also set a 50-year default time period for operators to monitor and provides financial assurance for correcting action for carbon sequestration projects. There are no similar limits on existing wells for hazardous waste of enhanced oil recovery. EPA appears to be balancing the importance of CCS technology for climate change against the potential long-term risk of large scale CO_2 sequestration. The committee will pay close attention and ensure this balance is correct, and we do not unduly start shifting risk from the atmosphere to underground sources of drinking water.

The Department of Energy's National Energy Technology Lab and the U.S. Geological Survey are assessing our Nation's capacity for carbon sequestration. Breakthroughs in capture technology will be of little use unless we sequester the CO_2. For economic reasons, we know a lot about oil and gas formations, but they are estimated to be, only, about four percent of the total capacity. We know less about the deep saline aquifiers that are the biggest potential for sequestration.

Some of our witness who will be displaying maps of our current assessments and describing the status of their efforts, in particular we are interested in the status of the USGS effort to rank potential sequestration sites for capacity and risk.

With that, I yield back my time and again I recognize our ranking Member, Mr. Shadegg of Arizona, and good to be working with you.

OPENING STATEMENT OF HON. JOHN B. SHADEGG, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ARIZONA

Mr. SHADEGG. Thank you, Mr. Chairman, and I am pleased to be here. I apologize for my slightly tardy arrival and I look forward to working with you. I want to congratulate you in your new capacity. I think we can do a lot of good and I am encouraged to see the subcommittee re-engaging in its work.

I cannot imagine a more important time for us to cooperate on the issues before this subcommittee as America is clearly energy challenged, at the moment, and we face a number of grave issues, including the question of global warming and greenhouse gases and their effect on our environment. With your permission, Mr. Chairman, and the unanimous consent of the committee, I will put my written statement into the record and just make a few comments.

I want to thank you for holding this hearing. I think it is extremely important. As you know, we are looking at carbon capture and sequestration and as we move toward a carbon constrained world, it is pretty clear that that may be a part of the technology that we move forward with in this country. Coal makes up a substantial part of the energy production in this country today. In 2007 coal fueled almost half or 48.7 percent of the electricity generated in the United States. If we are to continue to rely on our vast quantities of coal, then indeed CCS technology appears likely to be a part of the equation.

However, coming from a State like mine, of Arizona, where water, literally, is life and death, and where we often joke that whiskey is for drinking and water is for fighting, it is of grave concern to me that we examine the process by which we capture and

sequester carbon and if we are to do it in the earth, in caverns located underground, the environmental impacts of doing so. I believe it would be a grave error for us to move forward with technologies that trade one environmental problem, the impact of carbon on our air and on our overall environment with another environmental problem and that would be the impact of carbon capture and sequestration on our water supply.

So I think this is an extremely important hearing. I note that a number of States are already moving forward to restrict new carbon producing coal fired power plants because of lack of the ability to capture and sequester the carbon produced and that makes it very important that we move forward with this technology and that we learn of the environmental impacts of what is being proposed, so I look forward to the hearing testimony today. I will put my full statement into the record and I am anxious to work with you, Mr. Chairman, as we go forward.

[The prepared statement of Mr. Shadegg follows:]

STATEMENT OF HON. JOHN SHADEGG

Thank you Mr. Chairman. I'd like to start by welcoming you to your new capacity on the Subcommittee. I look forward to working with you.

Today's hearing is focused on the sequestration of carbon dioxide as it relates to drinking water. This issue is part of a much broader picture. The United States' demand for energy is expected to rise by 19% by 2030. In 2007, coal fueled almost half of electricity generated in the United States. As we move towards a carbon-constrained world, many believe carbon capture and sequestration (CSS) technologies should be part of the equation, to not only continue to meet our current demand but to also meet our future demand with American made coal.

A large part of deploying CCS technologies is tackling the cost of both the capture technology and the transportation of the carbon dioxide to storage sites. However, at issue today, is the sequestering of the carbon dioxide and what potential this process may have on drinking water.

Last Tuesday, EPA issued a proposed rule on carbon sequestration under the Safe Drinking Water Act's Underground Injection Control program. As we will hear from our witnesses today, this program seems appropriate given EPA's past experience. However, I have two major concerns.

First, a large-scale project has not been demonstrated in the United States. A more realistic understanding of the entire CCS process seems necessary before we create a full-scale regulatory regime. For example, we understand that sequestered carbon may be very mobile in various geological sites. However, we do not understand how a large plume of carbon dioxide may move through these geological sites or where the displaced liquids will go. And this is particularly important to my home state of Arizona where we have carbon storage potential but also a large water supply from underground aquifers most likely to be affected by carbon sequestration. In fact, Arizona has two sole source aquifers - the Upper Santa Cruz and Avra Basin Aquifer and the Bisbee-Naco Aquifer that may be particularly at risk. We must be careful not to trade one environmental concern - carbon dioxide emissions - with another - contaminated drinking water.

Secondly, I am seriously concerned that liability has not been addressed by the EPA proposed rule. It is important for businesses to fully understand all the rules of operation- not to only understand half of the rulebook. While I understand the complexity of determining liability issues, I do not think that the nation is served well by Washington bureaucrats ignoring the issue. Planning to address the issue at a later date is inappropriate. Businesses in America face enough uncertainty with regulation. We should not arbitrarily expose them to liability issues. Carbon emissions are already impacting the business decisions of today's energy providers and it is important the Federal government provide certainty in their regulations to aid future business decisions before creating a massive regulatory regime. I look forward to addressing these and other issues in our question and answer period. Thank you.

Mr. GREEN. Thank you, Mr. Shadegg. Next opening statement is Congresswoman Baldwin, Wisconsin.

OPENING STATEMENT OF HON. TAMMY BALDWIN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF WISCONSIN

Ms. BALDWIN. Thank you, Mr. Chairman, and let me join my colleagues in congratulating you on your new role on this subcommittee. I look forward to working with you and moving forward on many important environmental matters that this subcommittee will examine. You are beginning your chairmanship on a very strong note with today's hearing focused on carbon sequestration.

Deployment of carbon capture and sequestration technology is critical if we are going to drastically remove greenhouse gas emissions from the atmosphere, and doing so is critical because, as we know, climate change is real and it poses serious threats to our economy, our environment and our national security. Certainly as we move forward with legislation to address climate change, we must ensure that the various technologies we deploy are safe and effective.

We already know that we have the ability to capture and even inject carbon dioxide into the ground. In Wisconsin we have a very exciting, first of its kind in the United States, carbon capture pilot project at a coal fired power plant. It has the potential to capture 90 percent of the CO_2 it emits from one percent of the flue gas being captured. Unfortunately, though, it is a catch and release program, at this point, as the ability to have large-scale sequestration is not yet available nationwide and may never be available in a State like Wisconsin due to our State's geologic formations. As future pilot projects come online that do have sequestration capabilities, proper regulations must be in place to ensure the safety of the American people and our drinking supply.

I commend the EPA for taking the first step in laying out proposed regulations that would govern the underground injection of carbon dioxide and I hope to learn more about how the administration feels large-scale sequestration can become viable.

And among the issues that I hope our witnesses will touch upon today are, what are the liability issues associated with sequestration? In other words, who will be held responsible if there is a significant leak affecting our water supply? What are the standards that must be set to ensure the safety of the injection wells? For instance, how do we protect these wells from corroding and are there monitors that can be placed on the wells to alert us if something is going awry? And, finally, if different carbon capture technology is used, is it possible that carbon dioxide composition would be different, and if so, does this present an issue in terms of sequestration capability?

Mr. Chairman, I apologize that I will have to leave the hearing early this morning, for other commitments. However, I am hopeful that some of these questions will be addressed through the course of your discussions today, and I thank you and yield back the balance of my time.

Mr. GREEN. Thank you, and members have the right, if we don't get to your questions, you can submit them and I think that is

great. Our next opening statement is Congressman Murphy from Pennsylvania.

OPENING STATEMENT OF HON. TIM MURPHY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF PENNSYLVANIA

Mr. MURPHY. Thank you, Mr. Chairman. It is good to see you at the helm here, and I am excited that you would choose such an important topic as carbon sequestration because it is so vital in the interest of our Nation such as our family security, our job security, our economic security and our National security as we are facing the challenge of our generation, that is energy. This Congress has debated a lot, not necessarily as much as I would like to see on issues involving energy when it comes to oil. But coal and the issues with coal are often times pushed aside, so it is vitally important we deal with this issue and start to deal with it today.

Our energy demands in this country are going to double by about the year 2050. That means, right now, the 400 coal-fired power plants, many of them with inadequate scrubbers and no scrubbers, need to be rebuilt in ways that eliminate pollution. We are also going to need to about double that—the number of coal-fired power plants, and that means that if we are going to meet those demands by 2050, we are going to have to have a ribbon cutting ceremony for new coal-fired power plants starting year 2010, every two and a half weeks. We have not even started building, in fact, some contracts have been cancelled, much of that because we are trying to deal with the issue of carbon sequestration, an issue we have to deal with.

Now, we only have two options for eliminating the emissions in coal-fired power plants. One is to close the plant, you have zero emissions—zero energy and the USA loses so much of its electricity it cannot only—cannot sustain growth, it cannot keep the manufacturing sector up and light our homes, our farms and our factories. The second thing is to solve this issue of carbon sequestration.

I am pleased that in southwestern Pennsylvania where we have one of the National Energy Technology Labs, they have been doing some pretty remarkable work on dealing with the carbon sequestration issue. It is one that we have to make sure as a Congress and as a Nation, we fund this so we can solve this problem. While we have 250 to 300 years worth of coal, we have far more energy than the Saudi's may have in oil and we ought to be using American energy, and American know-how, and American energy to solve America's energy problems.

We are going to need to continue to develop these technologies, to map out systems and ensure that anything we do is safe and sustainable. So whether we are looking at injecting CO_2 into rock or into the ground sites, we have to make sure that we also negate any risk involved with that to the environment too. We don't just want to—we don't want to just postpone environmental problems, we want to solve them.

Other issues, of course, are not just carbon sequestration, but actual carbon transformation. We are using other plant life, et cetera, we can convert to carbon, back into oxygen and other elements, as well. Well, with all that, this is a vitally important meeting and vitally important hearing because this is a critical component in our

Nation's—solving our Nation's energy problems. I look forward to hearing the testimony today, along these lines. Thank you, Mr. Chairman. I yield back.

Mr. GREEN. Thank you. Our next opening statement is our—and welcome to the committee for a good friend, Congresswoman Matsui.

OPENING STATEMENT OF HON. DORIS MATSUI, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Ms. MATSUI. Thank you, Mr. Chairman. I would like to join my other colleagues in welcoming you to this new post and we look forward to working with you, and thank you for calling this important hearing. And I would like to also thank today's panelists for joining us and discussing the important issue of carbon capture and storage. I look forward to hearing all of your expert opinions.

Carbon capture and storage is a subject that has been getting a lot of attention lately, as we look to ways of dealing with the urgent matter of climate change. Only two weeks ago we heard in the Energy and Air Quality Subcommittee about prospects for conducting research and demonstration projects in carbon capture and storage. Then, as now, my first concern is public safety. The evidence is clear. We must take actions to seriously address the issue of climate change. It will be a massive undertaking.

To tackle this enormous challenge, we must have all available resources at our disposal. Carbon capture storage is likely to be one component to a comprehensive approach to addressing this problem along with many others, such as energy efficiency, solar, biomass and wind. But our constituents need to be confident that we can use any new technology safely and effectively and carbon capture remains to be fully tested.

My home State of California already has many environmental risk factors, from contaminated ground water to active geologic faults. So we must ensure that any new technologies we use do not adversely affect the health of our population. While we must embrace new technologies, we cannot do so at the expense of clean water, clean air or our constituent's safety.

As a mother and now a grandmother, I am constantly reminded of the importance of leaving a safe, livable and stable planet for future generations. That is why, now, we must address climate change, but we must also consider, carefully, how to proceed wisely and with the appropriate safeguards. I look forward to learning more about the ways we can ensure that carbon capture storage is used safely. Mr. Chairman, I thank you for your leadership and your commitment to these issues. And I yield back the balance of my time.

Mr. GREEN. Thank the gentlewoman. Congressman Terry.

Mr. TERRY. I will waive opening statement at this time. I appreciate that.

Mr. GREEN. Congressman Hill.

Mr. HILL. I will pass on an opening statement, Mr. Chairman, other than to say congratulations for ascending to the helm here. We all know that you are going to do a good job.

Mr. GREEN. Thank you. Congressman Barrow.

Mr. BARROW. I thank the Chair and I want to add my congratulations to my beatification as the Chairman of this subcommittee. I am looking forward to working with you. This is an incredibly important subject to my part of the country where the utility customers rely, to a much greater extent than we would like to, on sources of energy that emit a great deal of carbon into the atmosphere. So this is very important to us, so in the interest of time and getting to the panel, I am going to waive any further opening statement, but Mr. Chairman, thank you for your leadership in calling this hearing and I look forward to working with you on this issue. Thank you very much.

Mr. GREEN. Congressman Radanovich, do you have an opening statement?

Mr. RADANOVICH. No, I will pass.

Mr. GREEN. Okay, thank you. That concludes our opening statements and we will turn to our first panel. Again, I want to welcome, not only our first panel, but our second panel today on this very important issue. Of course, coming from Texas where we have an interest in carbon sequestration already, and producing in more hydrocarbons, we have some working experience with it. But I would like to welcome the Honorable Benjamin Grumbles, the Assistant Administrator of the U.S. EPA Office for Water; Mr. Scott Klara, the Director of the Strategic Center for Coal and the Department of Energy's National Energy Technology Lab that Mr. Murphy mentioned and also Dr. Robert Burruss, Research Geologist for the Energy Resources Team at the U.S. Geological Survey. I welcome each of you and each of you will give 5-minute statements. We will start with you, Mr. Grumbles.

Mr. GRUMBLES. Thank you, Mr. Chairman. I am Ben Grumbles, Assistant Administrator for Water at the U.S. EPA.

Mr. GREEN. Mr. Grumbles, if you could hold just a minute. Ranking member.

Mr. BARTON. Is it—am I in time for an opening statement?

Mr. GREEN. If you would like to give one.

Mr. BARTON. Very quickly.

Mr. GREEN. Okay.

OPENING STATEMENT OF HON. JOE BARTON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Mr. BARTON. You want to hear the first part of it Mr. Chairman. I want to congratulate you for taking this gavel of the Environment and Hazardous Material Subcommittee. For once, I have to say your sides got it right. You actually know a lot about this subject. Your district has a huge number of petrol-chemical facilities. Nobody has worked harder to protect the environment during your time in the Congress, than you have. And on a personal level, you are a fair and reasonable person and very approachable. And, you know, we were very pleased to have Mr. Wynn, when he was here in your position, but you are a worthy successor and I am absolutely certain that this subcommittee and the full committee is going to be better because of your leadership. So it is really good to see you in the Chair. I appreciate that a lot.

This hearing is an important hearing, Mr. Chairman. Many members of the full committee have joined the subcommittee Chairman, Mr. Rick Boucher, of the Energy and Air Quality Subcommittee, myself included, in sponsoring bills—a bill to develop the technology for carbon capture, carbon conversion and storage. Ultimately we want to see this concept become an option in the energy mix for the United States of America, but first we have got to understand all the facts of the issue.

In resolving one environmental issue, we need to make sure that we are not starting another. The EPA has begun to explore what underground injection of carbon dioxide or CO_2 might mean for underground sources of drinking water. I want to commend Assistant Administrator Grumbles for getting out ahead on this issue. Let us understand these issues as soon as possible so that as the project developers design their systems that make whatever scientific parameters are necessary to protect our drinking water supplies, how liability is addressed under CERCLA and RCRA, however, is very muddy water indeed. EPA's proposed rule from last week does not address any of the liability issues surrounding CO_2 sequestration and underground sources of drinking water. Without an understanding of the liability framework, it is extremely difficult for members and their constituents to make an informed decision on the proposed rule.

We also need to better understand the varieties of geologic formations, how they compare as suitable hosts for underground injection. If the best formations are not close to power plants capturing the CO_2, that raises a huge logistics issue.

I think that the issues already identified in Mr. Grumbles office and others with regard to injecting CO_2 into the ground should cause us to take another look at carbon dioxide conversion technology, converting CO_2 into a solid substance such as sodium bicarbonate or what most people would call baking soda is already underway at an experimental site in my district, down in Texas.

Large-scale application of this process would yield more baking soda than we probably need, but there are other applications too, and it is dramatically easier to store than the gassiest form of CO_2.

In short, Mr. Chairman, we have got a lot to learn in this area, and I am happy that our witnesses today are going to begin the process of educating us. I want to welcome them all, especially Mr. Grumbles, who has served so professionally in a particularly difficult job at EPA. I look forward to today's testimony. Thank you again for your courtesy in allowing me to give an opening statement on my tardy arrival. With that I yield back.

Mr. GREEN. Thank you Mr. Barton, and I appreciate your friendship for a number of years, and I always joked that sometimes when Congressman Barton and I talk we don't have to have an interpreter to understand our language. If we could ask your forbearance, our Chairman is on the way, and having learned a long time ago that that is why our office has been across the hall from Chairman Dingell for almost a decade now, even though we could move to a larger one, it is so convenient to make sure I can talk to the Chair, and—

Mr. BARTON. We have got an oversight hearing on long-term healthcare and that is where he and I both were.

Mr. GREEN. And I am also on that committee and I have an interest in it, if I could ask unanimous consent for the Chair to give his opening statement when he arrives and that way we can start with our witnesses, if our witnesses don't mind being interrupted.

Mr. GRUMBLES. Not at all.

Mr. GREEN. Mr. Grumbles, again, welcome.

STATEMENT OF BENJAMIN GRUMBLES, ASSISTANT ADMINISTRATOR, OFFICE OF WATER, U.S. ENVIRONMENTAL PROTECTION AGENCY

Mr. GRUMBLES. Thank you, Mr. Chairman. I am Ben Grumbles, Assistant Administrator for Water at U.S. EPA, and it is an honor to be the first witness to congratulate you on your new post. I know that we share the same goal and that is accelerating environmental progress while maintaining our country's economic competitiveness and energy security, and it is a delight to be able to discuss with committee members the subject of geologic sequestration, and in particular the first ever rule that we have just proposed that Administrator Johnson signed on July 15 that would provide a National framework for safe and effective geologic sequestration and help make significant strides towards mitigating greenhouse emissions.

Mr. Chairman, what I would like to do in the brief amount of time in the terms of the opening statement, is to emphasize, first of all with respect to climate change and efforts within the EPA and the administration that we are committed to taking timely and aggressive actions to confront the serious challenge of global climate change by harnessing the power of advanced climate change mitigation technologies such as carbon capture and geologic sequestration. We are entering a new age of clean energy where we can both be good stewards of the earth and good stewards of the American economy. The Intergovernmental Panel on Climate Change has estimated that CCS, the process of capture, transport and storage of CO_2 has significant potential and can reduce domestic CO_2 emissions to the atmosphere from 15 percent to 55 percent over the next century. U.S. EPA is excited about advancing that effort and the Office of Water, in close collaboration, with the Air Office and the Research Office work together so that the Administrator would be in a position to propose this rule that he signed on July 15.

Mr. Chairman, geologic sequestration is not the silver bullet, but it may be an ace in the hole, and it is important for us to continue to have this dialogue with our State and local partners and with Congress on this National framework for regulatory consistency, and site specific flexibility to ensure that carbon dioxide is injected safely for long-term storage.

This is also a part of the Office of Water's climate change strategy that we have published in draft form and are anticipating finalizing in the fall. The highlights of the rule, the extensive rule that we proposed, Mr. Chairman, are that we are creating a new Class VI under the Safe Drinking Water Act's UIC program, Underground Injection Control Program. Our experiences are based on 35 years of experience under the existing UIC program, including the Class II. As you Mr. Chairman know, in your State, there has been significant activity, particularly under Class II for enhanced

oil recovery. The lessons we learned from that are invaluable as we move forward to finalize this rule in late 2010 or perhaps early 2011.

Our rule would require that geologic sequestration wells are appropriately located, constructed, tested and monitored. Siting requirements would include provisions for ensuring the site is thoroughly evaluated to ensure CO_2 will not migrate to the surface. Construction requirements would include provisions that wells be constructed with corrosion resistant materials to prevent the well from corroding over time. There are also provisions included for periodic review of the area around the injection well to allow for adjustments as the fluid moves underground.

Mr. Chairman, a central, fundamental part of the rule that we are proposing is monitoring, continued monitoring and testing, both for scientific integrity and also public acceptability to reduce the potential for any risks from the carbon—geologic sequestration. We have also included proposed requirements for financial responsibility to assure the funds would be available for well plugging, site care, closure and emergency and remedial response.

We believe we have developed a framework that will ensure safe injection in the present and safe storage in the future. Mr. Chairman, we have a 120 day public comment period that will probably begin tomorrow when the rule appears in the Federal Register. During that time, I want to assure you that we will be continuing our robust collaboration with our State and local partners, with the scientific community, with other Federal agencies such as DOE and USGS—with everyone to continue to move forward in a positive way that does continue to protect underground sources of drinking water while also making significant steps towards mitigating greenhouse gas emissions.

Mr. Chairman, I look forward to the testimony of our colleagues, particularly Federal partners and also our State and local partners who have been working closely with us on this proposal, and I would be happy to answer questions as they arise.

[The prepared statement of Mr. Grumbles follows:]

TESTIMONY OF

BENJAMIN H. GRUMBLES
ASSISTANT ADMINISTRATOR
FOR WATER
U.S. ENVIRONMENTAL PROTECTION AGENCY

BEFORE THE
UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ENERGY AND COMMERCE
SUBCOMMITTEE ON ENVIRONMENT AND HAZARDOUS MATERIALS

July 24, 2008

Thank you, Chairman Green and Members of the Subcommittee. I am Benjamin H. Grumbles, Assistant Administrator for Water at the U. S. Environmental Protection Agency, and I appreciate the opportunity to discuss the Agency's important work on carbon dioxide (CO_2) storage and our new regulatory proposal under the Safe Drinking Water Act (SDWA) on geologic sequestration. This first–ever rule on geological sequestration (GS) will provide a national framework for regulatory consistency and environmental safety, as well as necessary flexibility based on geological settings.

This Administration is committed to taking timely and aggressive actions to confront the serious challenge of global climate change. By harnessing the power of advanced climate change mitigation technologies such as carbon capture and geologic sequestration, we are entering a new age of clean energy – where we can be both good stewards of the Earth, and good stewards of the American economy.

Carbon dioxide storage can be achieved through several approaches. Before discussing EPA's proposed rule for geologic sequestration of CO_2, I wanted to briefly

mention two other approaches that hold promise, but which are largely outside the scope of the proposed geologic sequestration rulemaking.

The first type of long term storage is terrestrial sequestration, which relies on vegetation to remove CO_2 from the atmosphere. Carbon dioxide captured by terrestrial sequestration is isolated in biomass and soils. This type of sequestration has helped to offset CO_2 in 2006 as a result of improved soil and forestry maintenance.

In addition to the carbon sequestration benefits, terrestrial sequestration activities can have significant environmental co-benefits important to protecting our Nation's resources, including reduced soil erosion, improved water quality, improvements to wildlife habitat and biodiversity, and reduced flooding.

Another type of sequestration is sub-seabed sequestration. Sub-seabed sequestration is the process of taking CO_2 from industrial and energy- related sources, transporting it offshore, and isolating it in offshore geologic formations. The proposed rule will apply under the SDWA to sub-seabed sequestration beneath ocean waters within a State's territorial boundaries. In addition, the Senate is currently considering U.S. ratification of the 1996 Protocol to the London Convention on dumping of wastes, a treaty which explicitly regulates sequestration of captured CO_2 in sub-seabed geological formations. On June 20, 2008, the Administration sent proposed legislation to Congress that would implement that provision under the Marine Protection, Research and Sanctuaries Act (MPRSA).

The focus of our rulemaking and this hearing, however, is on geologic sequestration associated with Carbon Capture and Storage (CCS). This promising technology provides an innovative solution for reducing emissions of (CO_2) to the atmosphere, while safeguarding our country's underground sources of drinking water.

The Intergovernmental Panel on Climate Change has estimated that the process of capturing, transporting, and storing CO_2 through CCS can potentially reduce domestic CO_2 emissions to the atmosphere from 15% to 55% over the next century. Storage is carried out through geologic sequestration, which consists of injecting carbon dioxide that has been captured from an industrial or energy-related source into deep subsurface rock formations for long-term storage. It is not a silver bullet for our climate change challenges, but CCS could help to reduce emissions while scientists around the world work to identify cleaner technologies to power our energy needs in the future.

EPA's Strategy on Water and Climate Change

Consistent with our desire to mitigate emissions and adapt to climate change, EPA's National Water Program has developed a draft strategy to respond to specific potential impacts on water programs, define goals and objectives for responding to climate change impacts, and recommend a comprehensive package of specific response actions. As you might expect, geologic sequestration technologies and environmental safeguards under the Safe Drinking Water Act play a key role in the strategy. In addition to regulations developed under the SDWA, the Office of Water has been involved in other efforts to manage climate change.

The draft strategy contains 46 specific actions EPA's Water Program will take to respond appropriately to climate change in topic areas including adaptation, mitigation, education, and research within our authorities in the SDWA and Clean Water Act. After extensive internal EPA review and coordination with other agencies, the Office of Water released the draft Strategy this March. Since then, we have received comments from the public and met with scientists, regulators, and policy makers and plan to finalize the

document this fall. Along the way, we will continue to take proactive and practical steps to address climate change, for areas related to geologic sequestration outside of the SDWA authorities.

EPA'S Proposed Regulations for Geological Sequestration

One of the primary actions identified to help mitigate the effects of climate change is geologic sequestration (GS), which is regulated under the Safe Drinking Water Act's Underground Injection Control (UIC) program. Over the past several years EPA has coordinated with the U.S. Department of Energy (DOE) to support carbon dioxide storage as a technology. We released guidance in March 2007 to facilitate permitting of DOE pilot projects for geologic sequestration. Last fall Administrator Johnson announced EPA's intent to develop regulations and I am pleased to report that the Administrator signed the proposed regulations last Tuesday, on July 15th. These proposed regulations will help to create a consistent, national framework for the large-scale injection of carbon dioxide underground, while protecting our vital underground water resources.

The UIC program is focused on protecting public health by preventing injection wells from contaminating underground sources of drinking water. EPA's proposed regulations build on more than 35 years of experience in the UIC program of safely injecting fluids, either liquid, gas or slurry, including CO_2, into the subsurface. Annually, billions of gallons of fluids are injected underground through wells authorized under State and Federal UIC Programs. This includes approximately 35 million tons of carbon dioxide that are injected for the purposes of enhancing oil and gas recovery.

Currently, wells used to inject CO_2 can be permitted as UIC Class I industrial wells, as Class II oil and gas wells (if used for enhanced recovery of oil or gas) or as Class V experimental wells (under our March 2007 guidance). However, because CO_2 has unique physical characteristics, we believe it is important to make adjustments to our existing UIC program that will respond to these characteristics. The buoyancy of CO_2, its potential corrosivity when in water, the potential presence of impurities in captured CO_2, its mobility within subsurface formations, and the large injection volumes anticipated at full scale deployment, have all been considered in requirements tailored to the new practice of injecting CO_2 for long-term storage.

EPA's proposal would create a new well type – a Class VI UIC well. Our regulations would require that geologic sequestration wells are appropriately located, constructed, tested, and monitored. Siting requirements would include provisions for ensuring that the site is thoroughly evaluated to ensure that CO_2 will not migrate to the surface. Construction requirements would include provisions that wells be constructed with corrosion resistant materials to prevent the well from corroding over time. The proposal includes provisions for periodic review of the area around the injection well to allow for adjustments as the fluid moves underground, and incorporation of monitoring and operational data to verify that the CO_2 is moving as predicted within the subsurface to protect underground sources of drinking water. We have also included proposed requirements for financial responsibility to assure that funds will be available for well plugging, site care, closure, and emergency and remedial response. We believe we have developed a framework that will ensure safe injection in the present and safe storage in the future.

EPA plans to publish a final rule in late 2010, or possibly 2011, depending on the data we receive. In developing a proposal to meet the fast pace of developing CCS technology, EPA will take into account any new data and DOE demonstration project outcomes. The Agency is using an adaptive management approach that will allow us to collect information and use data from the DOE demonstrations and other early projects to inform the final regulation and any subsequent revisions, if necessary.

UIC Authority to Require Air Monitoring at the Surface

In issuing regulations for permitting under the UIC program, we have authority under the Safe Drinking Water Act to require monitoring for injected CO_2 that may be released back into the atmosphere. Under Section 1421 of the law, EPA is mandated to protect underground sources of drinking water from endangerment by underground injection. Under this authority, EPA may require an owner or operator who is injecting CO_2 to determine if an underground source of drinking water is endangered, including surface air monitoring. This authority can extend to the post-injection period of a well as long as an underground source of drinking water has the potential of becoming endangered by the injected CO_2.

While subsurface monitoring forms the primary basis of protecting underground sources of drinking water, near-surface and surface monitoring could be a last line of monitoring. Under the proposed regulations the Director has the discretion to require surface air monitoring/soil gas monitoring in the area of review. Near-surface and surface monitoring could help to determine if leakage to an underground source of drinking water has occurred and could also help to identify the general location of the leak.

Financial Responsibilities Related to Well Operation

Financial responsibility for well operation has been a part of UIC requirements for deep wells since inception of the program. The Safe Drinking Water Act does not have explicit provisions for financial responsibility, as is included under the Resource Conservation and Recovery Act. However, EPA uses the general authorities provided under the law to prevent endangerment of underground sources of drinking water, including by setting standards for financial responsibility to prevent endangerment of underground sources of drinking water from improper plugging, remediation, and management of wells after injection.

EPA is proposing to adapt existing financial responsibility requirements for deep Industrial Class I UIC wells to the new Class VI geologic sequestration wells to ensure that appropriate well closure and post-injection site closure takes place. The requirements for wells would include that owners and operators demonstrate and maintain financial responsibility and resources for 1) corrective action so that wells within the area of review do not serve as conduits for the movement of fluids into underground sources of drinking water, 2) injection well plugging, and 3) emergency and remedial response. These requirements are already in place for UIC deep wells. In addition to these requirements, we are proposing adding a requirement that owners and operators develop a plan and demonstrate and maintain financial responsibility and resources for post-injection site closure care before closing geologic sequestration sites.

SDWA authority does not currently extend to financial responsibility for activities unrelated to protection of underground sources of drinking water, i.e., coverage of risks to air, ecosystems, or public health unrelated to underground sources of drinking water

endangerment. It also does not authorize transfer of owner or operator financial responsibility to other entities, or creation of a third party financial mechanism where EPA is the trustee. EPA realizes there are long timeframes anticipated for geologic sequestration and these long timeframes have prompted interest in discussion of alternative approaches for providing stewardship after site closure. As a result, the Agency has prepared a supplemental document on approaches to geologic sequestration site stewardship to provide information about stewardship after site closure as a means of continuing this discussion. This document is available in the docket for the rule-making.

Coordination and Collaboration

Within EPA, the Office of Water and Office of Air and Radiation have worked together on all activities related to geologic sequestration in order to conduct technical and cost analyses, develop risk management strategies, collaborate with key stakeholders, and clarify the relationships among various statutes and EPA regulations. Our Office of Research and Development has also been involved in providing technical assistance and recently initiated a research program to study the potential effects of carbon sequestration activities on human health and the environment.

EPA is working closely with DOE to leverage existing efforts and technical expertise. EPA and DOE are coordinating with Lawrence Berkeley National Laboratory to answer key technical questions regarding impacts on groundwater and underground formations. The Agency is also working closely with researchers at other labs including the Pacific Northwest National Laboratory and Lawrence Livermore National Laboratory, and is monitoring international projects such as Sleipner in Norway, In Salah in Algeria, Weyburn in Canada, and Otway in Australia, to help inform the regulatory framework.

DOE is conducting demonstration projects to gather data on the effectiveness and safety of GS. DOE is implementing many small and large-scale field tests of carbon dioxide injection throughout the country in a variety of geologic settings. In addition to facilitating initiation of pilot projects, another goal of the technical permitting guidance EPA issued in March of 2007 is to promote the exchange of information to support the development of a long-term geologic sequestration management strategy.

EPA will continue to engage with the Department of Transportation, Department of Interior, as well as other federal agencies, States, and Tribes during the rulemaking process. EPA has worked closely with key organizations such as the Groundwater Protection Council (GWPC) and the Interstate Oil and Gas Compact Commission (IOGCC), which represent States that implement UIC programs, and we will continue to do so throughout the regulatory process. For example, the Agency has reviewed the IOGCC report entitled "Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces." The document's discussion of issues such as permitting and property rights may be very useful as we finalize regulations.

In addition, the Agency has worked directly with states, including by inviting

them to participate on EPA's rulemaking workgroup as implementing partners. Four states participated in EPA's workgroup, representing Alabama, Ohio, Texas, and Arkansas. I want to express my appreciation to Larry Bengal, who will be on the next panel, for participating on EPA's workgroup, and providing the Agency with useful information in the development of the proposal.

Additionally, we are prepared to coordinate with the United States Geological Survey and the DOE through the Energy Independence and Security Act of 2007 to conduct an assessment of the geographical extent of all potential sequestration formations, the potential capacities and injectivities of these formations, and an estimate of the potential volumes of oil and gas recoverable from such efforts.

Over the past several years, the Agency has been holding workshops, attending conferences and meeting with public and private stakeholders including industry experts, legal experts, technical experts, and environmental advocates to gather useful input. We appreciate the participation of these stakeholders, and want to thank panel member Scott Anderson for attending our meetings and serving on panels at our technical and public workshops. Our past experience gives us confidence we can work closely with key stakeholders and experts to develop well-designed regulatory approaches to preserve our nation's underground sources of drinking water.

This past December, EPA held a meeting that focused on the potential regulatory framework for geologic sequestration. The two day workshop, held in Washington, DC, was attended by more than 200 stakeholders representing government, research institutions, industry, public interest groups, law firms, and the general public. A second meeting was held in February 2008 in Crystal City, Virginia where EPA provided a comprehensive review of how current UIC Program elements could be tailored for the

purposes of CO_2 injection for geologic sequestration. Furthermore, over the past year EPA has held technical workshops in New Orleans, Washington DC and Albuquerque with researchers and stakeholders to discuss technical considerations for establishing a geologic sequestration framework.

EPA plans another series of meetings to discuss the proposed rulemaking during the comment period, and will publish details about the upcoming meetings in the Federal Register next month.

Conclusion

Mr. Chairman, EPA is committed to continuing the important work underway to realize the significant potential of carbon dioxide capture and geologic sequestration.

We also recognize we are developing regulations even as CCS technology matures, and as vitally necessary pilot projects come online. Emerging information from experimental pilot projects, and from ongoing scientific research, will be critical to design the best framework for managing these wells and ensuring our many environmental safeguards and public health protections are effective. We will continue to work closely with other federal agencies and encourage participation of states, associations, public interest groups, industry, and other stakeholders to gather feedback on our newly proposed rule as carbon capture and storage technologies advance.

Thank you, Mr. Chairman and Members of the Subcommittee for this opportunity to describe EPA's important work on geologic sequestration. I would be happy to answer any questions you may have.

Mr. GREEN. Thank you, and now by unanimous consent, I would like to recognize our Chair of the Full Committee for an opening statement.

Mr. DINGELL. Mr. Chairman, I will not accept your kindness, but it makes me, nonetheless, grateful. Mr. Chairman, I ask unanimous acceptance my statement be included in the record and I take this opportunity to congratulate you on holding this very important hearing which is your first as the Chairman of the Subcommittee on Environment and Hazardous Materials, and I look forward to this being the beginning of a long and successful career in this capacity, as you grow in your service to the people of Texas and the United States. Thank you, Mr. Chairman.

[The prepared statement of Mr. Dingell follows:]

STATEMENT OF HON. JOHN D. DINGELL

July 24, 2008

Mr. Chairman, thank you, and I commend you for calling this important hearing, your first as Chairman of the Subcommittee on Environment and Hazardous Materials, to focus on the myriad of issues involved in sequestration of huge volumes of CO_2 in deep underground formations. I congratulate you on your new chairmanship and look forward to a close working relationship as the Subcommittee tackles very important public health and environmental issues.

We have distinguished witnesses before the subcommittee today, who can inform us as to the availability of storage sites in the U.S., the capacity of such sites, and the regulatory framework necessary to protect underground sources of drinking water.

Water is critical to growth and economic development in many areas of the country, and will become even more so in future years. In pursuing the goal of carbon capture and storage, a system must be in place that protects the quality of drinking water sources and assures the public that this is a safe way to proceed.

Approximately one week ago EPA released proposed regulations under the Safe Drinking Water Act designed to achieve these goals. I look forward to EPA's testimony and the views of our other witnesses on the adequacy of the proposed regulations and any gaps that remain to be addressed. I thank them for their presence, and I thank you, Mr. Chairman, for your vigor and your diligence in addressing these questions.

Mr. GREEN. Thank you. Dr. Burruss.

STATEMENT OF ROBERT C. BURRUSS, RESEARCH GEOLOGIST, ENERGY RESOURCES TEAM, U.S. GEOLOGICAL SURVEY, NATIONAL CENTER

Mr. BURRUSS. Thank you Mr. Chairman and members of subcommittee for the opportunity to testify today about geologic sequestration of carbon dioxide. My name is Robert Burruss. I am a research geologist with the U.S. Geological Survey. This morning I will review some basic principles of geological storage of CO_2 and also assessment methods. I will discuss risks associated with large scale storage projects and give you an overview of USGS activities.

Geological storage of CO_2 in oil and gas traps, saline formations and coal beds involves injection of liquid CO_2 at depths greater than about 3,000 feet, displacing the original fluids. In the subsurface, buoyant CO_2 rises until it is retained beneath a seal. If the seal forms a trap, it will accumulate like crude oil and natural gas accumulate in nature. This is called physical trapping. CO_2 also dissolves in formation, but only to a limited extent, causing solubility trapping. The solution is a weak acid that can precipitate new minerals, causing mineral trapping. However, the acid may

dissolve minerals mobilizing natural, but potentially hazardous trace metals and residual organic matter into the formation water. CO_2 is also highly soluble in crude oil, creating another type of solubility trapping and the drive for enhanced oil recovery. Large volumes of CO_2 remain trapped in the reservoir as additional oil is recovered. The value of that additional oil can offset the costs of carbon capture and sequestration.

USGS develops robust methodologies for consistent assessments of National and international resources of oil, gas and coal. As the Nation's lead agency for assessment of ground water resources, USGS provides critical expertise to evaluate saline formations. Consistent assessment of geologic commodities must distinguish well characterized potential reserves from much larger volumes of poorly characterized resource. Because oil and gas traps occur within saline formations and because they are the best characterized part of the larger formation, they are both—traps and saline formations are related geologically and are analogous to a potential reserve to trap and a resource the saline formation.

However, evaluation of storage volumes must include properties of the overlying seal because the seal is the critical factor affecting the risks of CO_2 leakage. Evaluation of risks of storage is dependant on the size of full-scale projects and the total volume of CO_2 stored as sequestration is fully deployed. For example, a 1,000 megawatt coal-fired power plant emits about 8 million tons of CO_2 per year. Over 50 years the total volume of CO_2 stored will be equivalent to about 4 billion barrels of oil. The number of traps of this size is limited and poorly matched to the location of large CO_2 sources. Multiple projects will displace progressively larger volumes of water each year, potentially disturbing natural ground water flow systems and displacing saline water into near surface environments.

Also affecting risk is the fact that the surface area above storage and saline formations may be as much as 20 times larger than the area for equivalent storage above traps. This is due to the fact that a much smaller fraction of the pore space is occupied by CO_2 stored in saline formations than in physical traps. The larger surface area increases the effort necessary to characterize risks of leakage and to monitor the site during the lifetime of a project.

Previous USGS studies, collaboration with DOE and State agencies, for example in the Frio Brine experiments, and USGS participation in EPA stakeholder meetings for its current rule making activity, provide new information for us to build a robust assessment methodology. The Energy Independence and Security Act authorizes USGS to develop a methodology and conduct a National assessment in cooperation with DOE, EPA and State agencies. Recently, USGS received funding specifically to develop the methodology. That work is proceeding. At completion, an independent non-USGS panel will be convened for external peer review of our methodology.

To conclude, USGS is using basic principles of sequestration and resource assessment to build a consistent methodology for CO_2 storage that incorporates risks associated with sequestration at the regional or basin scale. We look forward to collaborating with our colleagues in other Federal and State agencies on an assessment

methodology for CO_2 storage. Thank you for the opportunity to present this testimony. I will be happy to answer any questions.

[The prepared statement of Mr. Burruss follows:]

STATEMENT OF DR. ROBERT C. BURRUSS

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to present testimony on geological sequestration of carbon dioxide (CO_2), addressing opportunities, risks, and protection of drinking water resources within the United States. My remarks will briefly discuss some of the basic principles of geological CO_2 sequestration, provide an overview of current U.S. Geological Survey (USGS) activities on these topics, and address some of the fundamental principles of assessment of geological commodities that underlie USGS methods, including the types of uncertainties that can affect estimates of storage volume at the regional scale.

INTRODUCTION

The magnitude of addressing reductions in greenhouse gas emissions necessary to impact global climate change is significant because fossil fuel use, the major source of CO_2 emissions to the atmosphere, will continue for some time in both industrialized and developing nations. Geologic sequestration of CO_2 captured from large industrial sources of emissions is one of a number of technologies for carbon management that could be deployed to stabilize the concentration of CO_2 in the atmosphere. Although geologic sequestration is the topic of this hearing, geologic CO_2 sequestration alone cannot achieve the goal of stabilizing the atmospheric CO_2 concentration at a level that will have a meaningful impact on climate change. The magnitude of reductions needed may be on the order of 70 percent or more (IPCC, 2005), requiring all methods of carbon management in addition to geologic sequestration. These other methods include terrestrial sequestration, increased use of renewable biological sources, electricity generation by solar and wind systems, geothermal and nuclear power, increased efficiency in transportation as well as electric power generation, transmission, and end use.

Over the last nine years the USGS has engaged in several studies to evaluate geological and geochemical factors that improve our understanding of processes occurring during geologic storage of CO_2, the potential risks associated with storage of large volumes of CO_2, and some potential environmental impacts of geologic sequestration.

The USGS also collaborates with DOE on sequestration projects such as, the DOE-lead Geo-SEQ program, a consortium of National Laboratories working on monitoring technologies and simulation codes for carbon storage; the DOE-sponsored Frio Brine project in Texas; and review of the efforts by DOE to develop several large scale field projects throughout the United States.

More recently, Section 711of the Energy Independence and Security Act (P.L. 110-140), enacted into law in December 2007, authorized the Secretary of the Interior, acting through the Director of the USGS, to develop an assessment methodology and conduct a national assessment of geological storage capacity in collaboration with the Secretary of Energy, the Administrator of EPA, and the State geological surveys. USGS will collaborate with DOE to incorporate the results of the assessment into future revisions of the DOE "Carbon Sequestration Atlas of the United States and Canada". The cumulative advances from these earlier USGS studies and DOE-funded activities provide a basis for developing a methodology to assess the national capacity to store CO_2 and understand the potential impacts of large-scale deployment of geologic sequestration.

Subsequent to enactment of P.L. 110-140, the USGS received from Congress funding to initiate a new activity to develop the methodology to conduct a national assessment of carbon dioxide storage capacity in oil and gas reservoirs and saline formations. The USGS has also recently updated its website to promote the dissemination of information and research relevant to this new activity: *http://energy.er.usgs.gov/health—environment/co2—sequestration/*, and has assembled a project team to begin development of the methodology. The USGS will consult and collaborate with other organizations, as appropriate, including state geological surveys, the Department of Energy, the Environmental Protection Agency, other bureaus within the Department, and other stakeholders. This will help ensure, to the maximum extent possible, an efficient, effective, and coordinated effort. As with all USGS energy resource assessment methodologies, an independent non-USGS panel, consisting of individuals with relevant expertise and representing a variety of stake-

holder organizations, will be convened to provide a technical review of the methodology. The full methodology is expected to be released by spring 2009.

BASIC PRINCIPLES OF GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE

Geologic storage involves injection of liquid CO_2 into a subsurface rock unit and displacement of the fluid that initially occupied the pore space. This principle operates in all types of potential geological storage formations such as oil and gas traps, deep saline formations, coal beds, and other rock types.

At the pressures and temperatures that exist at depths in the Earth greater than about 3,000 feet, carbon dioxide is a supercritical fluid with density that ranges from 500 to about 700 kg/m3 at the greatest depths considered for storage, about 12,000 feet below the land surface. Because the density of CO_2 is only 50 to 70 percent of the saline formation water, the CO_2 will be buoyant and rise vertically until it is retained beneath an impermeable barrier, commonly called a seal. If the structure of the seal forms a trap with both vertical and horizontal barriers (closure), CO_2 will accumulate in the same manner that other natural buoyant fluids, like crude oil and natural gas, accumulate by displacing formation water from the geologic trap. This process is commonly referred to as physical trapping. Physical trapping of CO_2 involves two factors critical for evaluation of storage risks: the integrity of the seal and the total volume of water displaced by injected CO_2. The volume of displaced saline water relative to the volume of CO_2 injected must be understood to fully evaluate the potential for leakage, including the potential for contamination of drinking water.

Some of the injected CO_2 will dissolve in the subsurface formation water, a process known as *solubility trapping*. The solubility of CO_2 is relatively low, however, reaching a maximum of about 5 percent of the weight of pure water, and generally less, 2 to 3 percent of the weight of saline water. This means that for complete solubility trapping, each ton of injected CO_2 must contact at least 20 tons of formation water, possibly much more.

Another consideration is that dissolved CO_2 forms a weak acid, carbonic acid, which can react with other components dissolved in formation water. Carbonic acid can also react with minerals in the geologic storage formation, either dissolving them, or precipitating new minerals, a process known as *mineral trapping*. The acidified formation water may dissolve coatings on mineral grains, releasing trace metals and residual organic components to the formation water and to the supercritical CO_2, raising the possibility of mobilizing potentially hazardous, naturally occurring materials. This process increases the potential for saline water that is displaced from a geologic storage formation to contaminate shallower, potable water supplies if the displaced water can migrate to shallower depths.

If residual oil is present in a storage formation, CO_2 will dissolve in the oil as another type of solubility trapping. However, CO_2 is much more soluble in residual oil than in water. In fact, at pressures equivalent to depths of about 5000 feet in the subsurface, CO_2 is completely soluble in oil (also known as completely miscible). This fact, together with the physical effects caused by dissolution of CO_2 in oil, including the volume of oil swelling and the viscosity dropping, provides the primary mechanism for enhanced oil recovery (EOR) using CO_2. When the oil is produced from a well, the CO_2 dissolved in the oil is separated from the oil, recycled and re-injected to recover additional oil. In the overall process, some injected CO_2 remains in the geologic formation, equivalent to about 1 ton of CO_2 stored for every 2 additional barrels of oil recovered. At current prices for crude oil, this additional recovery is clearly a valuable "by-product" of potential CO_2 storage in depleted oil fields.

GEOLOGICAL RESERVES, RESOURCES, AND THE ROLE OF THE USGS IN CAPACITY ASSESSMENT

An assessment of the geological capacity to store CO_2 must be based on fundamental principles that are analogous with any assessment of a finite geological commodity such as petroleum or coal. Within the total possible volume of storage, we must be able to distinguish potential geologic CO_2 reserves from resources (Bachu and others, 2007). The resource is the quantity that, based on geological principles and available knowledge, may exist within some portion of the Earth. The reserve is that portion of the resource for which we have more information and thus greater certainty with which we can define a volume that can be evaluated with enough detail to assign a value to the commodity. For clarification, use of the term "reserve" in this testimony is broader and distinct from the term "proved reserves" which connotes economic evaluation of a known quantity of resource. The current and most precise definitions of the terms reserve and resource as they pertain to oil and gas accumulations are provided in a 2007 joint publication of the Society of Petroleum

Engineers, the American Association of Petroleum Geologists, the World Petroleum Congress, and the Society of Petroleum Evaluation Engineers (SPE, 2007). In the SPE terminology, the USGS assessment will focus on ″contingent resources″, a term indicating that additional economic factors must be evaluated before a value can be assigned, thereby shifting the volume of contingent resource to a reserve. In common usage ″probable reserves″ is synonymous with ″contingent resources″.

The USGS has a long history of conducting national and international assessments of natural resources. Given that geologic storage space for CO_2 in the subsurface is a finite geological commodity, USGS scientists have the necessary geological expertise to build a robust methodology for assessing geological CO_2 storage capacity. This expertise stems in part from many years of experience in conducting impartial, scientifically robust oil, gas, and coal assessments where a critical issue is the distinction between reserve and resource described previously.

Equally important in developing an assessment methodology is the significant expertise of the USGS in assessment of ground-water resources. The unique knowledge within the USGS of regional ground-water aquifer systems enables the USGS to develop methods to assess potential storage in saline water-bearing geologic formations. Although very large storage capacities can be calculated for saline formations, incorporation of geological and hydrological risk factors that affect these capacities is a challenging and difficult scientific task. These factors are essential to defining the portion of the total geologic CO_2 storage resource that is actually technically feasible to utilize and may ultimately meet the economic definitions of a reserve.

Conceptual framework for storage assessment

USGS methods for assessment of geological resources focus on evaluations at the regional or basin scale where we can define geologically consistent assessment units (AU). The application of a consistent methodology across these scales will facilitate aggregation of results from all assessment units, providing an overview of the national endowment of storage capacity. For CO_2 storage, the description of the AU should include information from two types of geological formations, the storage unit and the overlying regional seal. The most commonly described formation types for geological storage of CO_2 are depleted oil and gas fields, saline formations, and unmineable coal beds. For each storage type, a sealing formation must accompany the storage formation to prevent the buoyant leakage of CO_2 from the storage formation to shallower levels or to the atmosphere. The geological properties of the sealing formation provide a basis for evaluating the geological risk of CO_2 leakage from the storage formation that could cause contamination of shallower aquifers for potable water supplies or limit the effectiveness of sequestration if stored CO_2 can return to the atmosphere. The geological risk factors at the scale of the AU are distinct in scale from risks specific to individual CO_2 storage sites, where additional factors such as the integrity of existing well bores and cement must be taken into consideration.

Although CO_2 storage in known oil and gas traps and saline formations are commonly considered as distinctly different types of storage, in most cases they are geologically linked. The physical traps of oil and gas fields occur within almost every saline formation under consideration for CO_2 storage. Using the distinction between reserve and resource described earlier, the physical traps that have retained buoyant oil and gas for hundreds of thousands to hundreds of millions of years are the best characterized part of the saline formation in which we understand the integrity of the seal and the injectivity of the formation. These areas are typically the most well characterized settings for CO_2 storage, and in this context can be considered analogous to a reserve and the larger area of saline formation adjacent to the trap can be considered the resource.

We can make conservative estimates of storage volume based on the amount of oil and gas recovered from the trap. That initial conservative estimate of storage volume can increase through additional recovery of residual petroleum with enhanced oil recovery. Ultimately, it may be possible to fill the trap to the maximum capacity defined by the spill point of the trap. When a trap is filled to maximum capacity, if the saline formation extending beyond the trap is adequately characterized, then injection could continue and storage would ″spill″ into the larger volume of the saline formation. Alternatively, storage could be initiated in an adjacent trap in the same assessment unit or in a different assessment unit. This concept of conservative definition of an initial, well-characterized volume of a geological commodity (in this case, storage volume) that can grow over time as the geologic setting of the commodity continues to be evaluated is another way to describe the funda-

mental definitions of reserve, resource, and reserve growth that will be implemented in the USGS assessment methodology.

Although the geological relationships between the storage properties of the physical traps of depleted oil and gas fields and the properties of the larger potential storage volumes within the saline formation of the same assessment unit are clear, developing geologically sound mathematical methods to estimate the storage volume of saline formations is difficult for several reasons. First, the number of direct measurements of the properties of the storage unit and overlying seal may be very limited. A saline formation may have only one well penetration or no penetrations at all within a 100 square mile area. Even if there is one or even several penetrations of the formation, the amount of information available for characterization of the injectivity of the formation or the integrity of the seal may be limited. The limited data availability will not preclude estimates of storage volume, but it will result in large ranges of uncertainties in the estimated storage volumes. The largest uncertainties caused by sparse data may be in the uncertainties in risk parameters such as potential for leakage and/or the injectivity of the formation.

Risk parameters can be incorporated into numerical assessments of geological commodities such as storage volume in two distinctly different ways. Values can be assigned to risks on a standardized scale, the values for all risks totaled, and then the calculated volumes can be ranked by total risk. A more rigorous method is to assign a probability to each independent risk factor, and then multiply these factors to arrive at the overall ″riskiness″ of the storage volume. That overall risk factor is then used to reduce the calculated volume of potential storage. This method results in probabilistic ranges of storage volumes that can be compared between assessment units within a single basin or between basins and regions. This approach is analogous to the process underlying USGS assessments of oil and gas resources that we describe as ″fully risked″ and is the method we will incorporate in the USGS methodology for assessment of CO_2 storage capacity.

Another aspect of CO_2 storage in saline formations that impacts our evaluation of risk factors is the scale of storage projects and the volumes of CO_2 that must be injected into storage formations as geological sequestration is fully deployed. The CO_2 emitted by a single, 1000 megawatt coal-fired electrical generating station is roughly 8 million tons per year. If that CO_2 is captured and injected into the subsurface, it will displace about 84 million barrels of formation water. Over the lifetime of a single full-scale storage project of this size, for example, for 50 years, the total volume of CO_2 injected into the subsurface, and the volume of water displaced, will be equivalent in volume to about 4.1 billion barrels of oil. This volume corresponds to a 'giant' oil field, according to terminology used in describing oil field sizes. There are physical traps of this size in the United States, but the number is limited. The geospatial mismatch between size of storage needed for sequestration projects and the location of large sources of CO_2 has been addressed in a USGS report published in 2006 (Brennan and Burruss, 2006). If geologic sequestration is deployed to the extent that the Nation is storing about 500 million tons of CO_2 per year, equivalent to emissions from 50 to 60 coal-fired power plants of 1000 megawatt size, then we must recognize that the storage process will displace about 0.6 km3 or 172 billion gallons of formation water each year. Such large movements of saline formation water have the potential to disturb regional ground-water flow systems, possibly displacing saline formation water laterally or vertically to near-surface environments where it could contaminate shallower drinking water supplies or impact ecosystems.

The size of storage projects also impacts our concepts for evaluating risks of CO_2 storage. Estimates of the total area of a geological storage site will determine the area that must be characterized geologically and hydrologically prior to injection, monitored during injection, and then continually monitored for sometime into the future once the injection phase of the project ends and long-term storage begins. However, for the same volume of total storage, there is an important difference between storage in physical traps and storage in saline formations.

In a physical trap with lateral barriers to flow, injected CO_2 will fill a thickness of the formation up to a maximum defined by the spill point of the trap. Within that interval, CO_2 can occupy up to 50 or 60 percent of the pore volume of the formation. In contrast, the CO_2 injected into saline formations will rise vertically to the base of the sealing formation and spread laterally. Models of this process and experience at the Sleipner project in the North Sea show that the total fraction of pore space occupied by injected CO_2 is small, on the order of 2 to 5 percent, although in some geologically heterogeneous formations this fraction could increase to 10 to 20 percent. This difference between high efficiency of storage in traps and low efficiency in saline formations means that for the same quantity of CO_2 stored, the surface area above a storage site in a saline formation that corresponds to the spa-

tial extent of injected CO_2 in the subsurface will be at least 2 times larger to as much as 20 times larger than the area above equivalent storage in a physical trap. The larger surface area above storage sites in saline formations will increase the effort necessary to characterize risks of storage and to monitor the site during the lifetime of a sequestration project.

The focus of USGS evaluations of risks of geologic sequestration is at the regional or basin scale where the total volume of storage from deployment of multiple, full-scale projects may have the greatest impact on movement of formation water and injected CO_2. Evaluation of these risks is dependent on knowledge of the geology and hydrology of the regional assessment unit. This analysis of risks is different from the risks evaluated in the proposed EPA rules on geologic sequestration where the emphasis is on evaluation and mitigation of the risks at the scale of individual storage projects. USGS does not evaluate individual projects. However, the regional scale risks may impact individual projects. USGS collaboration with EPA on risk issues ranges from informal discussions about subsurface fluid flow and area of review with the Underground Injection Control Program, to USGS participation in the public stakeholder meetings that EPA held as part of the current rulemaking process. We look forward to closer collaboration with EPA as development of our methodology proceeds and during assessment of storage capacity.

Concluding Remarks

In this statement, I have summarized some of the basic aspects of geological CO_2 sequestration and described some of the fundamental concepts underlying resource assessments that the USGS is employing to develop a probabilistic methodology for assessment of CO_2 storage capacity in both the physical traps of depleted oil and gas fields and in saline formations. In addition, I have discussed some of the concepts of geological risk that must be incorporated into the assessment methodology. The present USGS work addresses the activity authorized under Section 711 of the Energy Independence and Security Act (P.L. 110-140) to develop an assessment methodology that can be applied consistently across the Nation. As noted above, the methodology development is being conducted in coordination with a number of organizations to maximize the usefulness of the assessment to a variety of partners and stakeholders, including the Department of Energy, the Environmental Protection Agency, other Agencies within the Department of the Interior, and State Geological Surveys.

Thank you for the opportunity to present this testimony. I will be happy to answer any questions you may have.

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Mr. GREEN. Thank you. Mr. Klara.

STATEMENT OF SCOTT M. KLARA, DIRECTOR, STRATEGIC CENTER FOR COAL, U.S. DEPARTMENT OF ENERGY

Mr. KLARA. Thank you Mr. Chairman and members of the subcommittee, and I appreciate this opportunity to discuss, today, the Department of Energy's research program on carbon sequestration.

My testimony today will, primarily, focus on sequestration capacity estimates. You will see some charts being shown on some background work that we have done that is included in your package,

but I would be happy to engage any other sequestration topics, as well, during the question and answer session.

DOE has taken a leadership role in advancing the development of sequestration technologies. Essentially, we are responsible for overseeing the development of the technology base. Through the carbon sequestration program, DOE is developing both the core and supporting technologies through which carbon sequestration could become an effective and economically viable option for reducing CO_2 emissions.

A key component to the program are the regional carbon sequestration partnerships. We are funding a network of seven partnerships to help develop the technology, infrastructure, and best practices protocols for implementing CO_2 sequestration in different regional settings throughout the Country. The seven partnerships that form this network currently include more than 350 unique organizations, universities, private companies, spanning 42 States, three Indian nations and four Canadian provinces. Collectively, the partnerships represent more than 95 percent of coal-fired CO_2 emissions, industrial CO_2 emissions, total land mass, as well as essentially all the geologic sequestration sites that have potential for storage.

Relative to the protection of drinking water, a key interest of this hearing, a key goal for the sequestration program is the development of technologies that will ensure safe practices. The program is addressing the key challenges that would ensure the safe, long-term permanent storage of CO_2, including the development of monitoring, mitigation and verification technologies to track the fate of the injected CO_2. The ultimate success of sequestration will hinge, in part, on the ability to measure the amount of CO_2 stored at a particular site, the ability to confirm that the stored CO_2 is not harming the local ecosystems and the ability to effectively mitigate any impacts associated with this storage. The program is developing the technologies and best practices to resolve these issues.

Relative to another key interest for this hearing, the sequestration program is working to ensure that adequate storage capacity is available for sequestration. Since 2003 we have been leading the regional carbon sequestration partnerships to estimate CO_2 storage estimates in different geologies throughout the United States and Canada. Some of those charts you see shown on the side views.

The first version of the carbon sequestration atlas was released in 2006. I show a copy in my hand. The goal of the atlas was to provide the first coordinated assessment of sequestration storage potential across the majority of the United States and portions of Canada, along with the methodologies used. The atlas focused on three types of geologic storage, oil and gas, unmineable coal seams and saline. The atlas relied on a team of geologic experts and scientists from across the country, including the United States Geologic Survey and representatives from nearly every State Geologic Survey. The atlas utilized an extensive set of databases maintained by the regional partnerships, USGS, EPA and EIA.

DOE maintains and analyzes all capacity information used to develop the atlas through a web based geographic system we call NATCARB, the National Carbon Explorer. NATCARB is publicly available on the web, is the world's first CO_2 source/sink database

that provides graphical interface to analyze regions of the country for CO_2 sources and geologic storage locations. NATCARB can be viewed as a portal that accesses databases maintained by others, for example, the regional partnerships, USGS, EPA, Department of Transportation and EIA. Therefore, NATCARB has immediate access to the latest updates on information relative to CO_2 sources/sinks and other properties.

Today, I have discussed the atlas from 2006, primarily. The atlas, however, is not a static document, but will be regularly updated as more data and insight are gained. The next updated version is due for release in November 2008. I present a draft copy here. The drawings you see shown represent information from the newer version of the atlas.

So, in conclusion, DOE's responsible for developing technology base. I have gone over most of our efforts today, relative to sequestration capacity estimates because it was of interest to the committee, and just note that these capacities estimates, along with the atlas and NATCARB are going to be critically important contributions to the Department's program and future updates and enhancements will help pave the way for wide-scale deployment of sequestration technologies. This ends my verbal remarks, thank you.

[The prepared statement of Mr. Klara follows:]

STATEMENT OF
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NATIONAL ENERGY TECHNOLOGY LABORATORY
U.S. DEPARTMENT OF ENERGY
BEFORE THE
SUBCOMMITTEE ON ENVIRONMENT AND HAZARDOUS MATERIALS
COMMITTEE ON ENERGY AND COMMERCE
U.S. HOUSE OF REPRESENTATIVES
JULY 24, 2008

Thank you, Mr. Chairman and members of the Subcommittee. I appreciate this opportunity to provide testimony on the U.S. Department of Energy's (DOE's) research efforts in carbon sequestration and, in particular, the Carbon Sequestration Atlas of the United States and Canada.

INTRODUCTION

Fossil fuels will play an important role in the Nation's future energy strategy. In a scenario of a future carbon-constrained world, successfully developing cost-effective technologies to mitigate the release of carbon dioxide (CO_2) into the atmosphere will permit the continued use of fossil fuels. Economic growth has been shown, among other things, to be tied to energy availability and consumption, particularly lower-cost fossil fuels like coal. To retain fossil fuels as a viable energy source, carbon capture and storage (CCS) technologies (also referred to as carbon capture and sequestration) is expected to play a pivotal role. Sequestration is a key climate change mitigation technology that the U.S. Department of Energy (DOE) is developing to ensure the continued use of fossil fuels in a possible carbon-constrained future.

On a global scale, CCS technologies have the potential, if deployed, to reduce overall climate change mitigation costs and increase flexibility in reducing greenhouse gas emissions.

According to a 2005 report on CO_2 capture and storage by the Intergovernmental Panel on Climate Change (IPCC), CCS technologies could account for at least 15% to as much as 55% of the global reductions in greenhouse gas (GHG) emissions, depending on the stabilization target level and timeframe for atmospheric concentrations of GHG. The IPCC report also states that technology development and improvements from industry and through research programs, such as DOE's Carbon Sequestration Program, could help reduce the current costs of capturing and storing CO_2 from power plants by 30% or more. A particularly beneficial aspect of certain CCS technologies is that their component parts – carbon capture, transportation, and storage – rely on technologies used and adapted from other commercial industries, thereby enhancing the availability and cost-competitiveness of CCS technologies as viable mitigation options.

DOE is taking a leadership role in advancing the development of CCS technologies. Through its Carbon Sequestration Program, managed within the Office of Fossil Energy and implemented by the National Energy Technology Laboratory (NETL), DOE is developing both the core and supporting technologies through which carbon sequestration could become an effective and economically viable option for reducing CO_2 emissions. DOE's research program has assembled government-industry-academic partnerships that are focused on developing the knowledge base, technologies, best practices and protocols to overcome barriers to the widespread deployment of CCS technologies so that sequestration can become a viable option in the near future.

A key goal for the Carbon Sequestration Program is the development of CCS technologies that will ensure safe practices, especially related to the protection of drinking water. The Program is addressing the key challenges that would ensure the safe, long-term permanence of CO_2 storage, including the development of monitoring, mitigation, and verification

technologies to track the fate of injected CO_2. The ultimate success of CCS projects will hinge in part on the ability to measure the amount of CO_2 stored at a particular site, the ability to confirm that the stored CO_2 is not harming the host ecosystem, and the ability to effectively mitigate any impacts associated with CO_2 leakage. A portfolio of technologies are under development that are being designed with a tentative goal of ensuring that after 100 years less than one percent of the injected CO_2 has leaked or is otherwise unaccounted for.

GEOLOGIC STORAGE POTENTIAL

Capturing CO_2 from fossil-fueled power plants is only one part of what is needed for sequestration to have a significant impact in reducing GHG emissions. Another major challenge is to ensure that adequate storage capacity is available for sequestration. Since 2003, DOE has been working with the Regional Carbon Sequestration Partnerships on CO_2 storage estimates in different geologies throughout the United States and Canada. In 2006, DOE released the first version of the Carbon Sequestration Atlas of the United States and Canada, which identified over 3,500 billion tons of potential storage capacity in deep saline formations, depleted oil and gas formations, and unmineable coal seams that potentially exist throughout these regions. This capacity, should it all prove viable, would be sufficient to store more than 600 years of the United States' total CO_2 emissions at current annual generation rates. As is typical of resource assessments, the economically viable storage capacity would likely be significantly smaller.

The 2006 Carbon Sequestration Atlas contains information on major CO_2 emission point sources, geologic formations with sequestration potential, and some terrestrial ecosystems that offer the potential for enhanced carbon uptake – all referenced to their geographic location to enable analysis of CO_2 sources and storage sites. An interactive version of the Atlas is publicly available through the National Carbon Explorer (NATCARB) website (www.natcarb.org).

CARBON SEQUESTRATION ATLAS OF THE UNITED STATES AND CANADA, 2006

The first version of the Atlas was released in 2006, as a result of cooperation and coordination among carbon sequestration experts in industry, academia, state, provincial, and Federal governments. The goal of the Atlas was to provide the first coordinated assessment of CCS storage potential across the majority of the United States and portions of western Canada. The Atlas also provides useful background information on the overall DOE Carbon Sequestration Program, and provides storage estimates for regions throughout the country, along with the methodology used to calculate these capacities. The Atlas relied on an extensive set of data collected by the Regional Carbon Sequestration Partnerships though December 2006. This represents the most comprehensive dataset on geologic formations with the potential to store CO_2. Without DOE's efforts, much of this information would likely have remained archived on paper or in separate databases. These efforts helped to resolve data quality issues between states that shared border and geologic basins. DOE and the Regional Carbon Sequestration Partnerships used these valuable digital datasets to apply a common set of methodologies to determine storage capacities that were applied consistently across all areas. The Atlas focused on three types of geological storage formations: oil and gas formations, unmineable coal seams, and saline formations. Other storage options are also being studied but estimates are not yet available for these unconventional storage options, such as basalt formations and organic-rich shale, nor are they expected to provide as much storage capacity as the formations that were studied. The Atlas relied on a team of geological experts and scientists from NETL and the Regional Carbon Sequestration Partnerships, including the United States Geologic Survey (USGS) and nearly every state Geologic Survey. The Atlas utilized an extensive set of information from databases maintained by the Regional Partnerships, the USGS National Coal

Resources Data System & Earth Resource Observation and Science (EROS) data center, the Geography Network, the Environmental Protection Agency (EPA) Emissions & Generation Resource Integrated Database (eGRID), and the Energy Information Administration (EIA).

DOE maintains all information used to develop the Atlas through a web-based geographic information system (GIS) – NATCARB, which is a relational database and GIS that integrates carbon sequestration data from key databases throughout the country. NATCARB is the world's first CO_2 source/sink database that provides a graphical user interface on the Internet and allows users to analyze regions of the country for CO_2 sources and geologic storage locations. Each of the Regional Carbon Sequestration Partnerships maintains a regional GIS and digital Atlas that provides NATCARB with constant updates to CO_2 emission sources and geologic capacity estimates. In addition, data for infrastructure, such as roads, rail lines, transmission lines, Federal boundaries, and municipal boundaries, are obtained from a number of different databases, such as EPA, USGS, and the Department of Transportation (DOT).

NATCARB is available "free-of-charge" on the Internet and receives more than 500 unique users per month. DOE and the NATCARB staff have supported many requests from other Federal agencies, industry, and researchers who are looking for information on geologic storage, and use the data to conduct detailed analyses of storage capacity in the United States.

Through NATCARB and the methodology created to estimate capacities, the 2006 Atlas of the United States and Canada was generated. The 2006 Atlas represents the first step toward gaining a comprehensive look at the potential for storage in the United States and parts of Canada. In the course of developing the storage estimates, it became clear that some areas had yielded more and better quality data than others. For example, a typical oil and gas field, which could be contained in a few square miles, could have hundreds to thousands of wells into a

formation that provides a wealth of data on the geology that, in turn, can be used to make accurate predictions of storage capacity. In contrast for some deep saline formations that typically underlie large areas, there may only be a handful of wells available to provide a basic understanding of the geology of the formation. This is the reality of the current knowledge of carbon storage in geologic formations. Prior to the DOE projects moving into the field, data were not previously collected with carbon storage in mind. As research in this area continues, additional and more comprehensive data are being generated and refined that will permit further improvements with future estimates. The methodology developed by the team of scientists and engineers represented by state geologic surveys, academia, industry, and national laboratories is considered to be a conservative approach and will be validated and refined after analysis of the data from the 30+ field projects that the DOE is implementing.

FIELD TEST PROGRAM, NATCARB AND THE ATLAS

The approach to addressing CO_2 sequestration depends on the fossil fuel use, and the type of geology at potential sequestration storage sites across the United States. DOE is funding a network of seven Regional Carbon Sequestration Partnerships to help develop technology, infrastructure, and best practices/protocols for implementing CO_2 sequestration in different geologies of the Nation. This approach includes engaging local organizations and citizens to contribute expertise, experience, and perspectives that represent their concerns and goals.

The seven Regional Carbon Sequestration Partnerships that form this network currently include more than 350 unique organizations, universities, and private companies spanning 42 states, and four Canadian provinces. Collectively, the seven Regional Carbon Sequestration Partnerships represent regions encompassing 97% of coal-fired CO_2 emissions, 97% of industrial CO_2 emissions, 97% of the total land mass, and essentially all the geologic sequestration sites in

the United States that are potentially available for carbon sequestration. With the Regional Carbon Sequestration Partnerships, DOE is evaluating numerous sequestration options to assess which are best suited for different geologies of the country, and is developing a test framework to validate and potentially deploy the most promising carbon sequestration technologies.

DOE's sequestration field test program is structured on a multi-phase approach. The first phase, called the Characterization Phase, was initiated in 2003 and focused on characterizing opportunities for CCS, identifying CO_2 sources and storage locations. The Characterization Phase was completed in 2005 and led into the current Validation Phase. This second Phase focuses on field tests to validate the efficacy of carbon sequestration technologies in a variety of geologic storage sites throughout the country. Using the extensive data and information gathered during the Characterization Phase, DOE identified the most promising opportunities for carbon sequestration and is performing widespread, multiple geologic field tests– more than 30 field tests in total. The geologic sequestration tests include projects in deep saline formations, unmineable coal seams, depleted oil and gas fields, and basalt. DOE is also addressing key infrastructure issues related to regulatory permitting, transportation of CO_2, pore space ownership, site access, liability, and public outreach and education.

The third phase of the Partnerships, the Deployment Phase, was initiated in Fiscal Year 2008. This phase is focused on conducting large-scale injection tests to confirm the application of CO_2 capture, transportation, injection, and storage at a scale near future commercial deployments. The geologic formations being tested during this phase represent vast geographic coverage, large storage capacities, and natural impermeable seals that are expected to ensure the safe long-term storage of CO_2. These geologic storage formations could serve as candidates for initial deployment of future commercial applications of CCS technologies throughout the United

States. Even though the field test program is being implemented in three phases, it should be viewed as an integrated whole, with many of the goals and objectives transitioning from one phase to the next. Accomplishments and results from the Characterization Phase have helped to refine goals and activities in the Validation Phase, and the knowledge gained from the Validation Phase is being used to enhance the Deployment Phase.

Over the course of these field projects, DOE will develop Best Practice Manuals on topics such as site characterization, site construction, operations, monitoring, mitigation, closure, and long-term stewardship. These Manuals will serve as guidelines for future geologic sequestration activity and help transfer the lessons learned from DOE's funded research to all stakeholders.

Data generated by each Regional Carbon Sequestration Partnership is maintained and updated locally or at specialized data warehouses, and assembled, accessed, and analyzed through NATCARB. As research continues within the second and third phases of the field test program, the data from the field tests and continued characterization activities will be available to refine and augment the 2006 version of the Atlas, leading to more accurate and improved versions in future years.

UPDATES AND FUTURE VERSIONS OF THE ATLAS

The Atlas is not a static document but will be regularly updated as more data and insight are gained. Since release of the *2006 National Carbon Sequestration Atlas of the United States and Canada (Atlas I),* the Regional Partnerships, NATCARB, NETL, representatives from the Carbon Sequestration Leadership Forum, various State Geological Surveys, and USGS have been working on developing an update. This update (*Atlas II*) is scheduled for release in November 2008. The primary focus of this update is to include additional basins and formations

to the CO_2 storage portfolio, refine CO_2 storage estimates, and clearly define the CO_2 resource and the uncertainties associated with the current estimates of capacity, and express the limitations on how this data should be portrayed. In addition, *Atlas II* will provide updated information on the location and quantity of stationary CO_2 emissions, the locations and storage potential of various geologic sequestration sites, Federal lands information for CO_2 storage, as well as an update on DOE's field activities. The investment made by the United States and its non-Federal partner organizations has resulted in a valuable national resource available to any individual, private company, and organization wanting to learn more about the role that carbon sequestration can play in mitigating GHG emissions.

CONCLUSION

Carbon sequestration will likely play an important role in mitigating CO_2 emissions under potential future stabilization scenarios. The Department's Sequestration Program is playing a key role in ensuring that carbon capture and storage technology, source/sink identification, and best practices and protocols will be available. The Atlas is an important part of this mission, and future updates and enhancements will help pave the way for wide-scale deployment of CCS technologies.

Mr. Chairman, and members of the Subcommittee, this completes my written statement.

Mr. GREEN. Thank you, and again, thank the first panel. We will proceed with our questions. And I will recognize myself. Mr. Grumbles, in his docket the EPA compiled a survey of indemnification programs used in other areas. In its rule making, the EPA analyzed liability under Safe Drinking Water Act of Superfund, but I am concerned about looking at indemnification without a complete picture of the liabilities. For the committee's benefit, can EPA compile a survey of all the potential legal sources, regarding liabilities for carbon sequestration projects, including the State and common law liability?

Mr. GRUMBLES. Mr. Chairman, I know we share your interests and concerns about potential liabilities and accountability of the owners and operators. We would be happy to work with you, work with the committee as we move forward on the rule making and get public comments. I know one of the areas—one of the priorities for us is to gain a greater understanding of the potential pros and cons of different types of liability programs. We make very clear, Mr. Chairman, and it is important to restate it here, that in this proposed rule making, the real focus is the technical requirements. It doesn't—it is not meant to address liabilities under other statutes or some of the other aspects— questions raised with carbon capture and sequestration. It is focused on the UIC program and Safe Drinking Water Act, but we would be happy to work with you and all your colleagues on the committee to compile information.

Mr. GREEN. Okay, thank you. EPA regulations currently define an underground source of drinking water as an aquifer less than 10,000 milligrams per liter of totally dissolved solids. The saline aquifiers considered for sequestration are higher than that level and thus are not currently considered the source of the drinking water. However, in many parts of the country, you are suffering from water shortages. And does the EPA proposal consider the possibility that some of these saline aquifers that we see on the DOE maps may be sources of drinking water in the future when purification technology continues to improve?

Mr. GRUMBLES. Yes it does, Mr. Chairman. I know you and Congressman Shadegg are also—and others are very interested in the potential for reclamation and reuse of ground water as well as surface water, so what we are explicitly doing is calling for public comment on the different standards that we have on the definition of underground sources of drinking water from freshwater to saline to brackish to brine, because we think it is important. We also know and have been working with, and are aware that municipal water authorities and others want to make sure that future sources of drinking water are not, in some way, endangered by this important carbon sequestration effort.

Mr. GREEN. The EPA rule making states that some injection activities may cross State boundary issues that are beyond the scope of this rule making. What are these issues and how will these issues be resolved if EPA does not intend to provide for these cross-boundary situations, because—

Mr. GRUMBLES. Well I—Mr. Chairman, I think that is one of the subjects that has come up in several of our workshops and I know that we are going to continue to review that, as the public comments come in on the proposed rule making. We recognize there is

a unique role for the U.S. EPA when it comes to trans-boundary issues, so that is one that I think we also benefit by close coordination with the committee and others on interstate and trans-boundary issues.

Mr. GREEN. And on our second panel, we can address some of that with the interstate compact commission. Does the EPA have adequate staff resources to manage a large increase in the UIC permitting due to sequestration, and what are their resources needed in this area?

Mr. GRUMBLES. Well, Mr. Chairman, we—as part of the President's budget request, we did request an increase to take into account the growing potential and promise of carbon sequestration. We have adequate staff and resources to get the rule proposed. We do believe this is a growth area, a great opportunity for the agency, but right now, we feel we have adequate staff and support. We also are sharing as much and benefiting from the Air Office and the Research and Development Office. We also know that the States have significant questions about resource responsibilities and impacts, you know, in implementing the rule that we proposed from last week.

Mr. GREEN. My next question of both Mr. Burruss and Mr. Klara, some of the testimony today indicates that the sequestration combined with enhanced oil recovery could produce 3.8 billion barrels of oil, just on the Texas Gulf Coast. As part of that sequestration assessment will DOE or USGS be able to provide estimates of potential recovery reserves from enhanced oil recovery? Is that possible?

Mr. KLARA. Absolutely, and, in fact, it is being looked at. The atlas and the information I present here today does not show enhanced oil recovery potential, but the Department has done some recent reports, trying to look just at that and especially in a carbon constrained world, where you might have the need to put a lot of CO_2 underground, and the potential looks pretty large.

Mr. GREEN. And my last question is, I know your surveys include storage capacity offshore, underground formations. Which agency is responsible for permitting any sequestration wells that would be offshore?

Mr. KLARA. That might be a better question for Mr. Grumbles, but I can say that in the EPA regulations, they do go, I think, 3 miles offshore and then beyond that it becomes more questionable, but I think that might be a good question to.

Mr. GREEN. Okay.

Mr. GRUMBLES. I would just say that our interpretation is consistent with Mr. Klara's that the UIC program, under the Safe Drinking Water Act, for sub-seabed sequestration projects in State waters, out 3 miles or in some cases 9 miles—the proposed Class VI rule would apply to those. We also have responsibilities under the Marine Protection Research Sanctuaries Act, which could also apply to carbon sequestration, geologic sequestration, sub-seabed injection projects in ocean waters and our general counsel's office and our office are looking at that subject too. But, definitely, the—in State waters, this Safe Drinking Water Act rule would apply to those.

Mr. GREEN. Okay. Thank you. Mr. Shadegg, questions?

Mr. SHADEGG. Thank you, Mr. Chairman. Let me begin by saying that I think we are operating in kind of a public atmosphere where the American people recognize that we had a recent experience with a congressionally approved practice that turned out to have unintended consequences.

Specifically, I am thinking about MTBE. We all thought we were helping the environment by using MTBE to oxygenate gasoline, and for a few years were very pleased with what we had done and then we discovered, oh my gosh, we were doing damage to our water supply, and we had to reverse all of those policies. And I think that is the kind of framework over which the American people will view whatever we do at this point.

I would like to begin, Dr. Burruss, by asking you, I guess two questions. One, to the extent that we are not sequestering carbon right now, but we are in fact using it in enhanced oil recovery, are we looking at and studying potential environmental damage done by that at the present time and evaluating it as a real life lab for whether or not there are potential environmental consequences for water supplies or for that matter, any other damage to the environment? And, if so, where are we looking at it and what volume of data do we have at this point?

Mr. BURRUSS. Congressman, we certainly have not conducted any studies specific to enhanced oil recovery projects for the environment over those fields. However, we do believe that it is an important—those enhanced recovery projects are important laboratories for doing—for learning more about the safety of storage and other potential environmental risks. I believe some of the partnerships may be working on some aspects of that. But, in general, I think we have not taken as much advantage as we could of the lessons from enhanced oil recovery.

Mr. SHADEGG. Mr. Klara or Mr. Grumbles, would you like to comment on that?

Mr. KLARA. Well, I guess I will make—the first comment is that, certainly, from a technology based standpoint, we are looking at nearly any risk you can imagine, and the path forward is to be able to quantify and assess those risks and come up with a risk assessment methodology that you can have a very high degree of confidence will result in safe practices.

And I think, coupled with that, with the EPA's experience with the underground injection code, and the fact putting regulations in place that have had some tried and true practice to show that things are safe if you follow certain requirements. I think coupling these risk assessment approaches we will be coming out with best practices and coupling that with the—for example, the Class VI guidelines that have just been proposed and modifications, perhaps, to those that, obviously, we need to make sure it is safe, but we believe that, from a technology standpoint, it has got to be driven with this technology risk-assessment approach.

Mr. SHADEGG. Mr. Grumbles, before I go to you, to let you comment on that question, I want to go back to you, Mr. Klara, and kind of burrow down a little bit. Would you agree with Dr. Burruss that while you are developing these methodologies, we have not yet implemented them to look at the impact of CO_2 when it hasn't been injected to enhance oil production in current sites? We are not

doing that. He says he doesn't think we are taking as much advantage of the opportunity to do that, as we should. I take it, you agree with that?

Mr. KLARA. Well, I think there is, maybe, two parts to that question. The first is, past practices relative to putting CO_2 in the ground for enhanced oil recovery, I believe have shown themselves to be safe, relative to the EPA guidelines.

Now, if you talk about putting CO_2 underground for 10,000 to 100,000 year storage, now that is a different question. And along those lines of questions, I would agree, completely, with your assessment that we need field projects.

And so, for example, within the DOE program we have 25 geologic field projects underway right now putting holes in the ground with small amounts of CO_2 to assess just that, and then we are leading up to much larger injection projects. And so, for example, we have best science practices right now that we are ready to publish, but we are waiting until best practices can be proven through many of these field tests.

Mr. SHADEGG. It is going to be important to me, before I vote, to do something like this, which is very important to be able to say to the American public, yeah, we made a mistake with MTBE, but we have done a better job of vetting this before we started to do it, so—and I am assuming, and maybe I am wrong, that looking at the fact that we have already done it with enhanced oil recovery, not for the intention of storing it, but the interaction between CO_2 and these, you know, kind of geological formations where we have been putting it is something we should be studying and looking at to see, well, does it escape? Can we adequately study where it is? And, when it does escape, does it do damage? Mr. Grumbles, did you want to comment on that question?

Mr. GRUMBLES. I just wanted to say a couple things, very quickly. And, one, I agree with everything the witnesses have said. Congressman, we do have quite a bit of experience, this country does, on the injection of CO_2 underground, and it is through the regulated programs, Class II, UIC regs that EPA and the States have carried out 35 million tons a year are injected for enhanced oil or gas recovery and we agree that it seems successful and it is a very promising approach.

This rule that we just proposed focuses on long-term storage at very large volumes of CO_2, different from the enhanced oil recovery and we think it is really important to get the public comment on the technologies and the extensive monitoring and the literature review that will continue to ensure that there is no endangerment to underground sources of drinking water, current or future.

Mr. SHADEGG. Or to other aspects of the environment?

Mr. GRUMBLES. That is correct, other aspects of the environment.

Mr. SHADEGG. My time is expired. Let me just quickly comment. I am concerned about the fact that the rule does not look at the liability issue and I am hopeful that the EPA will, in fact, look at liability under CERCLA and RCRA, as a part of informing us, because liability is something we have got to be concerned about on behalf of the American taxpayer.

Mr. GRUMBLES. And I would just say that what it does lay out, consistent with the 35 years of our regulatory program for other

classes under the Safe Drinking Water Act, it does insist upon responsibility of the owner and operator for proper site characterization for injection, for care of the site, for extensive monitoring, and for fixing the problem, if there is a problem.

The issue that is one that the rule does not address, and that I think everyone is interested in and having a robust discussion with policy makers and scientists is, on other types of liability, longer-term liability after the site has been closed, there is no more monitoring by the owner or operator, there are other environmental laws or statutes involved that—that is what the rule doesn't get into, but it definitely does hold owners and operators accountable with enforcement provisions to ensure that they remediate, if there is a problem.

Mr. SHADEGG. Thank you.

Mr. GREEN. Ms. Matsui?

Ms. MATSUI. Fifty percent of California's population is dependent on groundwater. It is really California's gold, and we are entering an era where we are really being affected by climate change already, so I am looking at all of this and I realize that there is some demonstration projects reoccurring in California regarding carbon sequestration. One of them is called Rosetta Resources, and I am interested in this because it is likely a first step in trying to determine—this is for you Mr. Klara—the safety and effectiveness of carbon sequestration in certain geological formations and it will only inject a small amount of carbon in comparison to the millions of tons that would need to be stored if this technology is to have a significant impact on the climate.

I am interested in whether the trial of this kind can legitimately assess the safety concerns we have, including pressurizing faults, releasing potentially harmful minerals, changing subterranean ecosystems and acidifying or polluting our groundwater. If such small-scale tests will not be an accurate portrait of the volumes and pressures necessary, what plans are in place to safely scale up these tests to generate a more accurate portrayal?

Mr. KLARA. The first step in the process is to do these smaller injection tests like you had indicated with the one in California. From there, we certainly agree that you want to go to a larger scale, and, at least within the Department's program, we have several approaches we are taking on that and one is to go forward with seven large scale tests, one in each of the regional partnerships throughout the country of at least a million tons or more.

We also have Clean Coal Power Initiative, and other activities that are trying to encourage us to do some larger scale tests. In addition to that, what we do too, is we look at what we call analogs, which was alluded to before, meaning that there has been a lot of work done for injecting CO_2 underground for enhanced oil recovery. There has been work done for storing natural gas and natural gas storage. And the science community is studying these, day in, day out to get the best handle of all the risk possibilities in a future where we would be injecting these large volumes.

Ms. MATSUI. Mr. Grumbles, this Rosetta Project is already delayed, partly because of regulatory hurdles, and how is the EPA working with State agencies like the California Division of Oil, Gas and Geothermal Resources to assure our constituents that all car-

bon capture and storage projects are safe and adequately overseen? And, also, will these pilot projects be permitted under the current regulations, or be subject to the draft rule being proposed and discussed today?

Mr. GRUMBLES. Thank you Congresswoman. First, the EPA entered into a memorandum of understanding with the Interstate Oil and Gas Compact Commission several years ago to work closely with them on areas of mutual interest to ensure environmental protection as it relates to oil and gas activities and carbon sequestration has been a part of that. And we have been working closely with all of the States that are a part of that effort, and they have a specific role with us, in the development of this rule and in reviewing the rule before we finalize it.

More specifically, one of the questions has come up that we do discuss in the preamble to the rule that was proposed and signed by the administrator on the 15th is the relationship between the Class V experimental well permits and this new Class VI, which is the extensive rule. And we describe, in the preamble, that pilot projects may continue to be carried out under that Class V experimental well permit as long as they are focused on research and are not of a commercial scale.

What we are learning is that adaptive management means, as we move forward to finalize this regulation with enforcement responsibilities to ensure drinking water, underground sources, are not endangered. We know that more and more pilot projects, in coordination with DOE and with States, are going to continue. They need to continue because they will help inform us about what the final contents of the regulation will be.

So we are going to be working closely with all of the States who are involved in this, which is an increasing number. It is very clear that States are showing leadership and strong interest in this geologic sequestration effort, too, and we are going to be working with them as we move to finalize the rule.

Ms. MATSUI. Okay, thank you Mr. Grumbles. My time is up.

Mr. GREEN. Mr. Terry?

Mr. TERRY. Thank you. I don't have as piercing of questions as my colleagues do, I am just curious, Mr. Grumbles, what are the known safety and health risks of CO_2 to drinking water? Have we already determined that?

Mr. GRUMBLES. We have a good idea as to the potential risks, and the key for us is that with proper siting and well construction specifications, and extensive monitoring the risks are not great, but the key depends on the siting and the following through on the nine or ten categories of extensive requirements that we are proposing in the Class VI rule.

What are the risks? One of the risks would be that as you are injecting the CO_2—while CO_2 is not a toxic substance, the risks are that at such volumes and high pressures, you could be pushing salt or other naturally occurring substances into an underground source of drinking water. That is one risk.

Another would relate to the CO_2, when it combines with water, can create a carbonic acid that can be corrosive, which can erode well—the infrastructure of the wells and that could lead to a leak.

So for us, we wanted to lay out a National framework that has very specific, technical requirements to address those various risks. We also recognize, Congressman, that over time the potential risks are likely to decrease, as long as the proper siting has occurred and the proper construction of the well and the proper carrying out and operation of the well.

It is important to underscore to everyone that our regulatory framework envisions that these deep injections would be occurring at least half a mile or more deep and that there would be multiple barriers of containment.

Mr. TERRY. Is that beneath most ground water?

Mr. GRUMBLES. That would probably be the case. We are going to take comments in the rule making process as to, you know, what instances might justify it being above some ground water supplies, if there were extra layers of protection and confining rock formations, but it is very deep injection, under very specific geologic conditions.

Mr. TERRY. All right, once again, I am just trying to get my mind around what the specific health hazards to humans are from CO_2.

Mr. GRUMBLES. Well, another could be that, you know, there could be chronic or acute health risks, breathing or risks to vegetation that could occur. So we are investing an enormous amount of effort in this drinking water—underground injection control regulation to make sure that the CO_2 would be properly sited and injected and would stay put and would be extensively monitored to try to prevent any type of risks, whether it is to ground water or other risks that might occur, but the focus of the rule is on using our Safe Drinking Water Act authorities.

Mr. TERRY. As I understand about CO_2, the greatest risk is as a greenhouse gas, not necessarily a health hazard specifically to humans, so if we can keep it underground, and it doesn't leach into the air, have we solved our CO_2 emissions issue?

Mr. GRUMBLES. Well we recognize that there is a need for a broad portfolio of technologies and strategies to successfully mitigate greenhouse gas emissions such as CO_2. Carbon capture and sequestration is not a silver bullet, but it has significant promise and—

Mr. TERRY. That ace in the hole, I think you said.

Mr. GRUMBLES. Well we—the Air Office, the EPA Research Office in very close coordination with the Department of Energy and, yeah, USGS and others, and internationally we are, just like DOE, we are traveling and learning from what other countries are doing in long term storage sequestration, underground of carbon dioxide, and it remains to us a very promising but unproven technology that we want to encourage carefully.

Mr. TERRY. And you were discussing with Ms. Matsui the pilot program and what popped into my mind is, I don't know of too many 10,000 year pilot programs. What do you perceive as the timeframe it would take to do a proper study of CO_2 sequestration so we can assure Mr. Shadegg's and my constituents that we aren't making an MTBE mistake?

Mr. GRUMBLES. Well, you know, I am going to also ask other witnesses, particularly Mr. Klara, to discuss the pilot projects because they have really been taking the lead on the various pilots.

What we have done, is we have recognized as these 30, or more, pilot projects move forward, there needs to be a management framework, so we proposed an experimental well permit for these research related projects to gather information. Very small scale compared to potential commercialization projects that our new rule would be addressing. And in terms of the time frames, we, you know, the information we have on them is—it is important to gather whatever information we can over a short period of time, in terms of the research projects.

Our financial responsibility provisions, under the Underground Injection Control Program typically are for 30 years for financial responsibility through site closure. And in our proposed rule we are saying, well let us start with a 50 year period, but let us make sure that it is not written in stone and that that can be adjusted, significantly, but I would defer to Mr. Klara on the scope of the research and pilot projects and the time frame needed for those.

Mr. TERRY. You are up.

Mr. KLARA. An obvious key is that we have to use the best risk assessment methodologies possible because, as you indicate, we can't be here 10,000 years from now and know what is going to happen. In addition to that, what we are doing too is looking at the mechanisms that trap the CO_2, and so for example, we are finding all kinds of interesting things that, literally, in a short period of time, years after you inject it, maybe 50 percent of the carbon dioxide is automatically locked up by many physical factors and we are looking at maybe accelerating those locking mechanisms, as well, as a way to, you know, permanently insure that it will be down there, but right now there definitely will be some CO_2 that would be amenable for leakage and through these field tests we are applying the best risk assessment methodologies we have at our disposal to take a look at 1,000, 10,000 years from now and try to make some indication and probabilities relative to the potential for leakage from those formations.

Mr. TERRY. Okay, I am just curious if there is, kind of, a time frame where we think we can move safely by taking it from a pilot project to, actually, encouraging or even mandating sequestration technology on any new coal plants.

Mr. GRUMBLES. Nothing in this rule from the U.S. EPA is mandating geologic sequestration. Let us be very clear about that. What we are doing is laying out the framework for the technical specifications and environmental safeguards.

We also think the key phrase here for Federal Environmental Regulation of this is adaptive management, so we have been striving in the proposed rule making to ensure that as the State regulators and as the EPA and the scientists involved in this learn more about it, we can adapt specific plans.

A key part of it, Congressman, is post-site closure, stewardship and responsibility and that is another subject that is going to need some more discussion, public and Congressional, and in the agency experts and extensive monitoring throughout the whole duration of the project and ongoing responsibility to remediate if there is a problem that were to occur, even after the site is closed.

Mr. GREEN. I would also like—and maybe in response to Congressman Hill's questions, you can talk about the expected life of

CO_2 within a formation, and I don't know if we are talking about 10,000 years, but that might be something that—but, Congressman Hill.

Mr. HILL. Thank you Mr. Chairman and panel members for being here. As a matter of fact, that was going to be one of my questions that the Chairman just asked, so why don't we just start off with that?

Mr. BURRUSS. We know from nature that there are many large natural CO_2 accumulations that have existed for millions of years, that the CO_2 has not all leaked out to the surface and the other important piece of information that we base all our understanding of how CO_2 will be stored in the subsurface really comes from our experience with producing oil and gas because they are buoyant fluids, just as CO_2 is a buoyant fluid in the subsurface. So that what we know about the processes that have retained oil and gas in the subsurface for many millions of years also apply to the retention of CO_2 in the subsurface.

Clearly, we have to have monitoring protocols and a number of issues we have to evaluate, but the fundamental principles of trapping and retention really come from what we know about oil and gas, and so I—from a geologists point of view, I think if we do it right, it is going to stay there for hundreds of thousand and millions of years.

Mr. HILL. What about in the event of an earthquake or something, would that change the reality?

Mr. BURRUSS. Clearly there is some risk that in an earthquake—a faulting event at the storage site could release CO_2, there is no question that that could happen, but even one question I pose to my colleagues in California who work on CO_2 sequestration and oil and gas resources is, you know, how many oil fields do we know leak during earthquake events in historic periods in California? We don't see that happen, so if we are careful we believe we can do this right.

Mr. HILL. Okay. I am trying to get my arms around how far along we are as it relates to sequestration. I had an environmental group in my office yesterday that it says it is not being done, shouldn't be done. I have been working with a company in southern Indiana, where I represent, that wants to change coal to gas and then sell the carbon to an oil company in Texas to sequester and to extract that oil. Mr. Grumbles, you indicated that there are, presently, 35 million tons now being sequestered. Is that on an annual basis? How far along are we?

Mr. GRUMBLES. That is an excellent question and the first thing I would say is not sequestered, but injected underground for enhanced oil recovery under the Class II Safe Drinking Water Act Underground Injection Control Program.

Then the question is, aside from that more focused use of CO_2, injecting it underground to enhance oil and gas recovery, what about long-term storage? You know the sequestration where you are mitigating greenhouse gas emissions by putting the CO_2 underground, and on that respect it has not—I know of—there are two sites in the U.S. where it is actually occurring. One in Texas and one in Michigan and about 30 or so sites that Mr. Klara and the Department of Energy can engage and describe in greater detail.

Internationally, there are some pilot projects and some larger scale, close to commercial-scale carbon sequestration projects, but as the Intergovernmental Panel on Climate Change said, I—you know, it is a very promising but unproven technology in terms of large-scale commercial, you know commercial size projects for—

Mr. HILL. But there are some commercial places in the United States and around the world that are sequestering and using it.

Mr. GRUMBLES. I would defer to them on the—in terms of the difference between commercial scale and larger than a pilot project.

Mr. KLARA. Right now, worldwide, there are three projects that could be viewed as commercial scale operations going to continue for as long as they need to continue for those operations, and viewed as being sequestration.

In the United States, all projects to date have really been pilot projects, just studying the concept, studying the phenomenon, relative to sequestration and when you indicate, well when is it ready, there is some subjectivity to that. But I will give you my comments on it, in that right now I don't think it would be difficult to go around the world with some of the best oil companies and say, can we find 10 sites that would be good for sequestration? And hence, that is why there are some commercial operations already in place, worldwide.

But if sequestration is truly going to have the potential impact it would likely need to have as a climate mitigator—CO_2 mitigator, we would need hundreds to thousands of deployments. So what we are doing from a technology development standpoint within the Department is saying, well, yeah, there are some projects, right now, around the world you can use all this oil and gas expertise from large companies and make it happen.

What we are doing is slowly trying to work the technology base in best practices to the point where we can then say, yes, it can be done at hundreds of sites, and so it, definitely, is an option that we should consider on a wide-scale deployment. And, right now, we have a timeline toward the year 2020 with a lot of metrics—technology metrics, in that, it would say that if all is successful, by that time, we feel that we will have a set of best practices, set of regulations like the stuff that are merging out of EPA, that would probably be the time frame where you can say, well wide-scale deployment of this probably can, now, occur in both the United States and the world.

Mr. HILL. Okay, let me clarify some things that have been said so that I understand, exactly, what you are talking about on sequestration. You mention, Mr. Grumbles, that presently we are using the carbon to extract oil in some places in the United States, and about 35 million tons have been sequestered as a result of that technology being used to extract oil. Is that—are you saying sequestration is—

Mr. GRUMBLES. Sequestered, in my mind, is a good word for long-term storage. And this is—it is being used instead, as a tool, to help enhance the oil recovery. It is really not being sequestered.

Mr. HILL. Okay. I don't know how much time I have Mr.—oh I see I have got the green light still. Mr. Grumbles, you indicated that—or in your testimony, you said that 15 percent to 55 percent

reduction over a certain number of years. Could you clarify what you were talking about there?

Mr. GRUMBLES. I can say that that was the findings and conclusions of the Intergovernmental Panel on Climate Change. It wasn't EPA but, I mean, we wouldn't disagree with that assessment. The statistic is being used to try to give policy makers a sense for the potential for carbon capture and sequestration to be used as a tool to mitigate greenhouse gas emissions.

Mr. HILL. Okay, so that 15 to 55 percent reduction, you are talking about reductions in the atmosphere?

Mr. GRUMBLES. That is correct.

Mr. HILL. Okay. Mr. Burruss, you talked about that the seal is the critical feature in making sure that we trap this carbon, could you expand upon that, somewhat?

Mr. BURRUSS. Yes, Congressman. Mr. Grumbles mentioned barriers and other things. Basically, the seal is a geologic formation that we commonly refer to as shale, in some cases and an evaporite or carbonate, but a rock that is impermeable to flow of fluids so that fluids do not go from some deeper level up to shallower levels through that barrier. In the hydrology community we refer to those as aquatards or aquacludes that prevent flow across that rock unit. And so, in what we envision as a storage unit or assessment unit is the actual geologic unit in which the CO_2 is injected and then the overlying rock that is—that prevents any vertical flow of the stored CO_2 or of formation water that is displaced by that CO_2.

Mr. HILL. Okay, I see my time has expired, but I do have one last question. And Mr. Klara, you talked about the seven regional partnerships that you want to put in place, correct?

Mr. KLARA. Yes, they are in place.

Mr. HILL. Does that replace the FutureGen project?

Mr. KLARA. No, it does not. FutureGen or any other large project would be complimentary to that. And probably, a distinct difference would be with the partnerships. They are focused, primarily, on the storage aspects and not the capture aspects at a power plant, and a thing like FutureGen or the Clean Coal Power Initiative, what that brings is the integration of capture at a power plant with the storage site.

Mr. HILL. Okay. Thank you, Mr. Chairman.

Mr. GREEN. Thank you, this gentleman's time expired. Mr. Radanovich.

Mr. RADANOVICH. Thank you Mr. Chairman, and thank you for this hearing. I represent the area in California, along with Ms. Matsui, that long strip in the central valley, and she is right. In California it is all about water. I am interested, Mr. Klara, in the depth of that saline water and is it as brackish as ocean water, and how much is there there?

Mr. KLARA. The determination, right now, on that is from an EPA ruling and you may have heard this 10,000 parts per million to total dissolved solids, but just—

Mr. RADANOVICH. I heard 10 grams per liter.

Mr. KLARA. Well, 10,000 parts per million, yeah. And so right now that is the requirement that we use to analyze whether you should even attempt to look at that saline formation as a possible sequestration option. We have the ability to, certainly, change that

parameter and do a reassessment, as appropriate, but right now we are using that as the guideline to say, what are potential targets of saline formations, based on that ruling to say that that water is very, very brackish, more brackish than sea water, typically. And, so those are the target formations under consideration right now.

Mr. RADANOVICH. And a sense of how many acre, feet or gallons that area represents? Any care to guess?

Mr. KLARA. Huge, massive.

Mr. RADANOVICH. Huge.

Mr. KLARA. Yeah, for example, with sequestration, it is likely and it depends on how the shares made throughout the world, in terms of mitigation reductions, but we could be looking at several great lakes worth of volume of carbon dioxide. It is miniscule, compared to the volume of saline water that is underground at these levels.

Mr. RADANOVICH. Can you tell me how deep that layer is?

Mr. KLARA. It varies throughout the country, but typically these will be greater than 5,000 feet deep, so half a mile-ish or more, deeper. And, in some cases, several miles, so these are very, very deep formations.

Mr. RADANOVICH. Okay, all right, and perhaps someone, I am not sure who can answer this question, but it seems to me that you are talking more about it in terms of groundwater, freshwater, groundwater pollution. This sounds like it is more of a—the potential hazard would be a displacement issue so that either the brackish saline water would be injected into the freshwater systems or, in the cases of oil, that oil itself would be—or CO_2 would be injected into freshwater. Is that a pretty fair assessment that possible problems would be contaminations of those three things?

Mr. GRUMBLES. I would say one of the risks is that the CO_2, not as a toxic contaminant, but in large volumes with great amounts of pressure, could be pushing, displacing other substances such as salts or other contaminants, or naturally occurring substances into the underground sources of drinking water. It is also very important for us to ensure that the CO_2 stream, that is injected, is as pure as possible.

I think you are right, Congressman, that is one of the risks that we see to—although I would say it is a low risk—if the siting and the monitoring and technical specifications are met that are in our proposed rule. The risks are displacement of other fluids that would, ultimately—or could get into a potential or current sources of drinking water.

Mr. RADANOVICH. Mr. Grumbles, you had mentioned a little earlier that, you know, we are talking 10,000 years or that is appears that the potential hazard diminishes over time because, I guess, nature underground adjusts itself. Is that what you—to the high pressure and it stabilizes over the long-term, or at least that is what you are experiencing or seeing?

Mr. GRUMBLES. That is what our observations are. I would defer to others for more scientific explanation, but I think that is the case. If after a certain period of time the plume has stabilized, then the chances are good that the risks would continue to decrease of it further mobilizing because of chemical or natural processes.

Mr. RADANOVICH. Do we have any evidence that sequestered carbon, at those depths are leaking, venting out somewhere now? I mean, does that occur in nature that—there are massive amounts that are locked up, I know, but is there a place on earth where, you know, it comes out of a volcano or something like that?

Mr. BURRUSS. Congressman, yes, there are many places in the world where there are natural CO_2 vents, commonly associated with volcanic activity or geothermal activity. In sedimentary basins, it is more common that the CO_2 is actually trapped, just like natural gas, I mean the naturally occurring CO_2, so we know that process happens and would prevent leaks. But there are, in fact, places in the world where naturally leaking CO_2 is a hazard to human health or ecosystems or, certainly, alters ecosystems, so we are learning from that information, as well. I mean the issue of natural analogs of, not only storage, but also of risks associated with leakage is coming from the geologic community.

Mr. RADANOVICH. In California, there is not a lot of coal out there and we depend, primarily, on natural gas for the generation of energy. If that potential shows in California, does that mean we can become a clean coal burning State? Does that mean that there is a pipe in the ground for every coal burning, electric-generation plant, or does that mean we are victim to the CO_2 pollution of Nebraska or Arizona or Texas?

Mr. KLARA. Well, I think that sequestration, unfortunately, is often thought of as a coal-based issue, but all fossil fuels, including natural gas, release significant quantities of carbon dioxide so my guess would be that in a carbon constrained future, that places like California would be very interested in doing something with CO_2 emissions from sources like natural gas.

Mr. RADANOVICH. Okay, it kind of broadens the energy sources that we have in order to generate electricity and such, right?

Mr. KLARA. Right.

Mr. RADANOVICH. Okay, very good. I appreciate this panel. It is a very fascinating subject. Thank you very much.

Mr. GREEN. Thank you. Our next questioner is Congresswoman Solis, I am going to ask you would take the Chair just for a few minutes.

Ms. SOLIS [presiding]. Thank you and I apologize, also, for coming in late and missing your testimony, but I do have some concerns, as well. And I think some of my colleagues on our side of the aisle, especially coming from California, the issues of keeping our water tables clean, as possible, and the amount of time and effort that the EPA has already put into keeping our water safe for drinking water. But my concern is the limitations.

I mean, the technology is clearly, we are looking at, but also the limitations that that might have, and my concern is while carbon dioxide may not be harmful in the atmosphere, as much as Mr. Grumbles has stated, when it does come in contact with water, it can become very corrosive and if there are other elements that are found in that sequestration, such as lead or arsenic, that can become very problematic. And I would like to hear a little bit about, you know, your response to that, Mr. Grumbles.

And I have some particular questions because in California we also have a very, I think, important issue going on there where we

are going through a drought. We are very concerned about preserving our water and we are looking at various storage facilities there, and because we are such a volatile area in California, with respect to earthquakes and I know that Mr. Klara might be able to speak about this, that there is preparation, also, for the big one, and we have had presentations before other committees to talk about what our preparation would be and what that would mean if there were a 7.9 earthquake and if I look at your map here, for California along the San Andreas fault, a potential for sequestration is pretty much along the fault line so I have concerns about that.

So, I will start with you, Mr. Grumbles, actually.

Mr. GRUMBLES. Thank you Congresswoman. A couple of points I would make are responses to those very legitimate, valid questions and concerns. One is, it is very important to us to insure that the CO_2 stream is as pure as possible, and so we have, in this proposed rule that the administrator just signed, we have defined it to exclude hazardous wastes for purposes of this carbon sequestration injection program, and we are also working with the Air Office as they continue to pursue technologies and issues associated with carbon capture in the Department of Energy.

It is very important, also, to emphasize the upfront, critical component of site characterization. That is the very first piece of the new regulatory framework we are proposing, and that is to put an extensive effort into proper characterization of the risks of a geologic setting and the area of review for potential movement of the plume. And so places that might be subject to earthquakes or volcanos or other—might have other various fractures are questionable and would require extensive analysis and modeling, because the key for us is safe and effective injection and containment of the CO_2.

Ms. SOLIS. If I can, Mr. Grumbles, I know that existing rules, right now, which apply to Class I wells and the injection of hazardous wastes in Class II wells enhance oil and recovery, appear to have owners and operators as remaining liable in perpetuity, but unlike this new proposed rule, we are placing a 50 year limit on that. And I wonder, then, who bears a financial responsibility after those 50 years?

Mr. GRUMBLES. We are seeking comment on 50 years. I wouldn't say it is a 50 year limit. It is a suggested time frame and the way it would work, Congresswoman, is that after a 50 year period of monitoring the site, and this is after the actual injection of the CO_2, it is for a 50 year period after the injection—continue to monitor the site.

It would also say that if continued, further monitoring is going to cease by the owner or operator, the owner or operator would have the burden to demonstrate to the director, to the regulator whether it is the State regulator or the EPA Federal regulator, that there would be no further movement or endangerment of that plume. The director would, then, be able to adjust that 50 year period, could make it longer, so it can change in various ways. It is meant for us to start the dialogue and the discussions and you get the public comments on what is a timeframe that owners and operators can get a sense for some upfront certainty as to where the

technical requirements are going to go and what their responsibilities will be.

Ms. SOLIS. I realize that some members on the panel have already asked about longevity, what happens after 100 hundred years, and what have you. I am very concerned about, again, contaminants that would have a corrosive effect on, even, the lining of these particular contained areas. And if there is movement how do you project that 10 years after, you know 60 years, that there is movement and that there is a leakage. And, then also with respect to your jurisdiction, if something does then expose itself to our atmosphere you clearly don't have any jurisdiction there.

Mr. GRUMBLES. In our proposal, we are suggesting that there be continuous monitoring and testing for movement of the plume. Not just upfront predictions of where it might go, which would be—all of that would be, you know, the adequacy of the site characterization and the area of review—risk characterization will all—those are all going to be critical as to whether or not a permit would be issued, in the first place. But even after it does, our proposed regulations lay out, what I believe is, an extensive array of requirements for continuous updating, in terms of the response and monitoring to follow the plume and take corrective action if, for some reason, there was a leakage along the way. You mentioned corrosivity. That is an area of concern for us too, Congresswoman, and we think it is important to make sure that there are no leaks or spills or movement of the CO_2 once it is injected.

Ms. SOLIS. My time is up, but I will hand over some other questions to you and the other panelists.

Mr. GRUMBLES. Thank you.

Ms. SOLIS. With that, I would like to recognize Mr. Pitts from Pennsylvania.

Mr. PITTS. Thank you, Madam Chair. Mr. Grumbles, you mentioned the 35 million tons of CO_2 injected annually for enhanced oil recovery and that that is done under your authority with the Underground Injection Control Program. I am trying to understand the magnitude of this. If you could translate that into a corresponding volume, 35 million tons, what kind of a volume are we talking about?

Mr. GRUMBLES. Well, I don't think I can. I can turn to staff. I will also be able to turn to the other panelists, either on this panel or on the second panel who can translate that into a volume. One thing that I wanted to emphasize, Congressman, is that 35 million tons is a huge number compared to the amount of CO_2 that has been injected for purposes of carbon sequestration, to date. We are still all experimenting with that and as Mr. Klara has pointed out, the long-term capture and long-term storage of CO_2 is very small compared to that 35 million tons.

Mr. PITTS. Mr. Klara, can you clarify?

Mr. KLARA. Yeah. A large power plant would put out around 8 million tons per year of carbon dioxide, compared to the 35 million that we are injecting for all of enhanced oil recovery. And just to give you a sense of the volume, 1 million tons of that 35 million would take up the volume of about the Empire State building. So it is about 35 Empire State buildings that are being put underground, relative to volumetric standpoint for enhanced oil recovery.

Mr. PITTS. Okay, and Mr. Grumbles or Klara, what is the source of that CO_2?

Mr. KLARA. The majority of that CO_2 is natural CO_2 taken from existing CO_2 reservoirs, at select locations throughout the United States and so the majority of that is natural CO_2 that is taken up from underground.

Mr. PITTS. How would you compare the purity of that CO_2 with what we would expect to derive from a coal-fired plant—power plant using carbon capture technology?

Mr. KLARA. Well, certainly, there are some CO_2 requirements for pipeline flow relative to corrosivity and issues that impact pipeline integrity. And the carbon dioxide capture from a power plant, we believe, would be at least that pure, relative for sequestration purposes. Now, as pointed out earlier, there are some trace components that we are studying, as well, to see if there is any impact of those. Right now those trace components are not issues relative to pollution or relative to hazardous emittance, but underground we are trying to be careful and study the chemistry and the physics of the flow just to be darn well sure that there is no impact from those trace components.

Mr. PITTS. Now, Mr. Grumbles, you mentioned several sites that you have selected for this. How did you choose those sites and what were the criteria you used in choosing them?

Mr. GRUMBLES. I don't believe we chose the sites. We have been in a supportive role with Department of Energy and with others. What we have done, is we have laid out our suggestions on a management framework for safe and effective carbon sequestration.

Mr. KLARA. Yeah, what we have done is, primarily through our regional carbon sequestration partnerships, is for years they have been evaluating potential sequestration locations as evidenced by some of the pictures you see on the posters and on the screen. And what we have done is develop understanding and characterizing where these storage locations were for several years and then when we started to get to the point of putting some small-scale projects on the ground, we picked some of the better, more likely locations that could be amenable to large-scale sequestration. And, so in a nutshell, that is how we selected.

Now along with that selection process, we have been following, even more extensively because it is a research project, than the guidelines proposed by EPA, so these have been, truly, science projects where we are throwing a lot of science, relative to risk and care, at these projects to ensure that we completely understand everything that is going on underground.

Mr. PITTS. Now, you mentioned 35 million tons of CO_2 injected, annually. How many years have you been doing this?

Mr. GRUMBLES. Since the Class II UIC program, which has been about 35 years.

Mr. PITTS. And you put this down with great pressure. What kind of pressure are you talking about?

Mr. GRUMBLES. Go ahead.

Mr. BURRUSS. Congressman, the pressure that—it is injected—at the surface, that pressure may be on the order of 2,000 PSIs, it is the pipeline pressure, but the—in the subsurface, it is the pressure that naturally occurs in the earth, in the oil and gas fields in which

it is injected, so it may be, you know, on the order of, you know, 5,000 pounds per square inch, or less or more, depending on the depth. But it is, basically, at the natural pressure. It doesn't raise the pressure, and if it does, those pressures are carefully monitored.

Mr. PITTS. So you are putting it down into voids, or are you pressuring it into—

Mr. BURRUSS. No, you have to—just to explain, enhanced oil recovery, in some respects is a large recirculation system. CO_2 and water are injected, oil and water and CO_2 come back. The oil is taken out, the CO_2 is collected and the CO_2 and the water are reinjected, so that process continues to circulate.

There is, basically, because oil and water were removed prior to CO_2 injection, there is no new volume that is necessary during EOR, in general. However, a lot of that is—essentially all the CO_2 that is injected stays in the formation unless it is removed by either venting or putting it back into a pipeline.

So, to come back to your question about 35 million tons a year, there are individual fields in west Texas that already have 50 million tons stored in them because injection has been going on for 30 years. So we have to keep in mind, there are some pretty large volumes in the ground that we put there.

Mr. PITTS. My time is up, thank you.

Mr. GREEN. Ms. Schakowsky?

Ms. SCHAKOWSKY. Thank you, Mr. Chairman. First let me apologize to the panel. There are other hearings going on, and so we are running back and forth here. Mr. Klara, is the 3 year carbon sequestration project in Decatur with Archer Daniels Midland, with ADM, one of the 30 you are talking about?

Mr. KLARA. Yes, in fact, that one would be in addition. The 25 geologic tests are small-scale tests, relative to several thousand tons of carbon dioxide. But Decatur is a large project with a million tons.

Ms. SCHAKOWSKY. Okay, I am sorry and 3 years meaning, is that the entire project or you are just going to monitor it for 3 years, or how does that work? You fill up in 3 years?

Mr. KLARA. Yeah, the length of the project is somewhat scientifically arbitrary, in that we want to make sure that we put a large enough volume underground that it is representative of what a large power plant might involve. And then what we do is once we get that volume underground, which in this case would be, roughly, a 3 year-ish period, we then monitor it for many years to understand the fate and the flow of the CO_2, our modeling, et cetera, et cetera, just to make sure that we really understand exactly where the CO_2 is going and what is happening.

Ms. SCHAKOWSKY. Now I know CO_2 is CO_2, but is there a difference in the technology if it is an ethanol plant, if it is a power plant, if it is an oil site—recovery site, or anything?

Mr. KLARA. Yeah, it is likely that there will be no difference. There may be some cases where, for example, CO_2 derived from maybe a power plant might have some trace components that an ethanol CO_2 would not have. Thus far we have not found those trace components to be of any consequence, but we are still study-

ing those, but in general we do not envision it being different from any of those sources.

Ms. SCHAKOWSKY. And so what is going to happen to the CO_2 once it is injected? Eventually, does it get capped or—

Mr. KLARA. Well, certainly you are not going to pick a formation unless you are sure that it has a lot of cap layers that would prevent the CO_2 from migrating, so that is a key factor to determine where you put the CO_2. In an example that you are presenting, those studies have been done to show that that is a very amenable formation that is capped. What we know, also, is after you inject CO_2 that with time, much of the CO_2 gets locked up by natural processes.

Ms. SCHAKOWSKY. What does that mean?

Mr. KLARA. What it means, for example, is it will get absorbed in the water. For example, it will turn into carbonate rock from mineral reactions and some capillary forces will stop some of the CO_2 from migrating.

Ms. SCHAKOWSKY. Mr. Terry was asking about the water. When you say it is absorbed in the water are we talking about aquifers?

Mr. KLARA. Well, these are salt formations—salt water. And salt water of such an extent that EPA has determined that, at least right now with technologies, they would never be considered for drinking water purposes. And so those are the target formations. It is a salt-briny water.

Ms. SCHAKOWSKY. How is this similar or different from the FutureGen project that we have been considering?

Mr. KLARA. We have several components in the program to demonstrate and prove the technologies. Relative to our partnerships and the case you point to in your State, that is looking at the storage side, primarily. But also there is the capture from a power plant side that we want to link with the storage, and so efforts like FutureGen and the Clean Coal Power Initiative are what bring that integration together. So there is all the storage issues where we are putting CO_2 in the ground and then there is the integration with power facilities and that is where a FutureGen or a Clean Coal Power Initiative would come into play.

Ms. SCHAKOWSKY. So what is the status of that project? And by the way, Dr. Burruss, if you want to add to this, because I am sure you are involved, and then the benefits.

Mr. KLARA. The status of which?

Ms. SCHAKOWSKY. The project, the ADM project.

Mr. KLARA. Well the status of the ADM project is that we are under cooperative agreement. All the, you know, government paperwork is in place. The funding is in place and right now they are doing an assessment of the area, starting to buy the facilities. So, for example, CO_2 compressor, et cetera, and with the schedule being, I think, injection in calendar year 2009.

Ms. SCHAKOWSKY. So that is when we actually begin to—what do you have to, dig the hole, basically?

Mr. KLARA. Well, yeah, exactly. So, right now, for example you have to drill wells. You have to get piping at the surface to transport the CO_2. You have to get a compressor so there is all these equipment purchases and equipment designs that have to be done. Plus reservoir modeling to make sure that we got a handle of the

best place to inject, et cetera. And that, typically, right now will take us, probably, the rest of this calendar year.

Ms. SCHAKOWSKY. All right.

Mr. KLARA. Before we would begin injection at that project.

Ms. SCHAKOWSKY. Okay, thank you. I am just about out of time. I thank you.

Mr. GREEN. Congressman Butterfield. Questions?

Mr. BUTTERFIELD. Thank you very much, Mr. Chairman. Thank you for recognizing me. You look mighty good in that chair and I look forward to working with you as we go on.

Mr. GREEN. I want to thank everybody, I appreciate it, so thanks for your comments.

Mr. BUTTERFIELD. Thank you. One of the worst things is to come into a subcommittee hearing late and start asking questions not knowing whether the questions have been previously asked. And so I have some written questions that I would like to go through and hopefully they have not been asked before I get here, but Mr. Grumbles thank you very much for coming back to the committee. I recall when you were here before and it's good to see you here again.

Mr. Grumbles, I wanted to ask you about gaps, or potential gaps in the EPA's authority to regulate injection activities for carbon sequestration. Is there a gap in EPA's authority to regulate releases of CO_2 coming up from an injection well or a sequestration project back to the atmosphere. Do you perceive any gaps?

Mr. GRUMBLES. Well, what I know is that as we proposed the rule, we wanted to make very clear that the rule does not include items outside the scope of the Safe Drinking Water Act authority, so as we proposed the rule and the administrator signed it on the 15th, in the discussions accompanying the rule, we point out a few things, Congressman, that get to the gap question.

One of them is that we recognize that a very important part of the public discussion is risks that might occur beyond, just, risks to underground sources of drinking water, so potential releases to the air or the environment, in some way, really don't come within the regulatory program or authorities under the Safe Drinking Water Act. However, we do point out, Congressman, that we do have the authority to include air surface, or subsurface monitoring for purposes of gauging whether or not the CO_2 plume is moving in some way or shape or form where it shouldn't be. So there is going to be some discretion for the director to require some monitoring that could include air surface—air monitoring.

We also point out that the regulations and the Safe Drinking Water Act do not include or contemplate transfer of liability or indemnification programs. So we point that out as an area for discussion for policy makers. And also in the context of financial responsibility, the focus of our programs, which is technically under the Resource Conservation and Recovery Act that we have been using, Congressman, for the history of the underground injection control program, is to include financial responsibility provisions relating to those various classes of injection.

For this proposed new class, this Class VI, for long-term storage, deep injection underground of CO_2, we do include some financial responsibility requirements, but we raise the question for public

discussion about—what about longer term financial responsibility after the site is closed and, you know, also relates to other types of risks, so those are some of the areas that we think it is important for Congress and for the public to comment on.

Mr. BUTTERFIELD. Let me read to you a quote from the proposed rule. I believe it comes from page 28, according to staff. The quote is, "However, regulating such surface atmosphere releases of CO_2 are outside the scope of this proposal, and SDWA authority." Is that an accurate quote from the rule?

Mr. GRUMBLES. Yes, that is, and that is an accurate view of the legal authorities, but it is also, as I mentioned, it is important to us and it is included in the text of the rule that there—that the director has the authority to require monitoring for potential releases to the air—surface releases if it is in some way connected to a potential risk of underground source—underground drinking water supplies. So there is extensive monitoring required but it is a fair statement and it is certainly something that we would stand by as pointing out an area for further discussion with Congress and other policy makers.

Mr. BUTTERFIELD. All right, thank you. I yield back.

Mr. GREEN. Thank you. This concludes our first panel, and again thank you for being here and appreciate the information, and again each committee member has a right to submit questions and we will submit them in the future. Our next panel, if we can change as quick as we could, I would like to welcome our witnesses and while you are coming up, I will introduce you. Lawrence Bengal, Director of the Arkansas Oil and Gas Commission on behalf of the Interstate Oil and Gas Compact Commission; Don Broussard, Water Operations Manager for Lafayette Louisiana Utilities; Ian Duncan, Associate Director of the Texas Bureau of Economic Geology with the University of Texas; Scott Anderson, Senior Policy Advisor for the Environmental Defense Fund in Austin, Texas; and Ben Yamagata, the Executive Director of Coal Utilization Research Council and a partner at Van Ness and Feldman. One of our scheduled witnesses, Professor Sally Benson, was unable to attend due to family circumstance, but she also is a recognized expert in the field. And, again, to our second panel, welcome and I would like to recognize each of you for 5 minutes and highlighting your prepared testimony, starting with Mr. Bengal. Again, thank you for your patience this morning.

STATEMENT OF LAWRENCE BENGAL, DIRECTOR, ARKANSAS OIL AND GAS COMMISSION

Mr. BENGAL. Good morning, Mr. Chairman and Ranking Members, members of the subcommittee. My name is Lawrence Bengal. I am the Director of the Arkansas Oil and Gas Commission and I am appearing here today in my capacity as Chairman of the Interstate Oil and Gas Compact Commission Task Force on Carbon Capture and Geologic Storage Task Force. I will share with the committee the experience and conclusions of the Task Force with regard to the geologic storage of CO_2.

I hope my testimony will demonstrate to the committee that States have a crucial and important role to play in the regulation of this most promising technology, the geologic storage of CO_2.

States have a keen interest in managing the good sites that occur within that State. Funded through the National Energy Technology Laboratory, the task force has been engaged since 2003 in efforts relating to the regulation of geologic storage of CO_2.

Although it may not be widely recognized, States are the primary regulators of oil and natural gas production and related activities including natural gas storage, acid gas injection and the injection of carbon dioxide, or CO_2 for enhanced oil recovery. Regulating the geologic storage of CO_2 is akin to regulating oil and gas production. States, therefore, possess much of the knowledge base that will be required to regulate CO_2 geologic storage.

Additionally, one of those important functions of the State in regulating oil and natural gas development is the protection of water resources. In most cases States are already the on-the-ground administrators of the EPA's Underground Injection Control (UIC) program, under State primacy jurisdiction granted by the EPA. With the advent of the model laws and regulations created by the Task Force, and released earlier this year, States have now begun to develop laws and regulations governing geologic storage of CO_2. At least 12 States have begun or are well along in this process.

This State-based regulatory system incorporates, as the oil and natural gas regulatory regime now does, EPA requirements under the UIC program as expanded to include the storage of CO_2. Additionally, Department of Transportation's Pipelines and Hazardous Material Safety Administration will play a critical role in ensuring CO_2 pipeline safety, which is also administered through State partnerships. The result will be a combined State and Federal regulatory system in the 2010 to 2011 timeframe that will provide a flexible, responsive, safe, environmentally sound and nationally consistent regulatory framework for geologic storage of CO_2. It should be more than adequate to get the first projects planned and safely off of the ground. If a need for additional Federal regulatory authority manifests itself, it can be addressed at that time.

Let me now turn to the diagram which illustrates the cradle to grave regulatory model, which the Task Force has recommended to States. As you can see, there are three phases. This will give you a quick idea of the breadth of the regulatory structure proposed by the Task Force, which is covered in more detail in my written testimony. I would note that only within the project area indicated by the green box does it appear that EPA has regulatory authority under the Safe Drinking Water Act. Areas not covered by EPA authority, however, can be addressed by State regulatory authorities.

Let me close by emphasizing that public support for geologic storage of CO_2, as a strategy for mitigating the impact of global climate change, will be crucial. Key to this support will be public understanding of the 30-year long history of CO_2 transportation, handling and use (including use to increase domestic oil production).

In this context, CO_2 should not be classified as a hazardous substance or pollutant under existing regulatory frameworks. Given the complexities of credits, ownership and usage of CO_2, a new regulatory paradigm is needed based on resource management, rather than waste disposal.

As such, it will be vitally important to include the public in every step of the regulatory development process, State and Federal.

State open meeting laws will ensure public notice and participation in the State process both at the legislative and regulation development stages.

Thank you for the opportunity to appear here today. If I can provide any additional information, please do not hesitate to ask. I would also ask that a copy of the full IOGCC Task Force Report be included in the record today. Thank you.

[The prepared statement of Mr. Bengal follows:]

TESTIMONY OF LAWRENCE E. BENGAL

Summary

Mr. Bengal will testify in his role as Chairman of the Task Force on Carbon Capture and Geologic Storage of the Interstate Oil and Gas Compact Commission (IOGCC). (The IOGCC is the nation's oldest interstate compact.) He will explain why it will be necessary for states to play a major role in the regulation of the storage of carbon dioxide (CO_2) in geological formations and what states are actively doing to prepare themselves for this important role. Mr. Bengal will testify that it is very likely that states will be the on-the-ground-regulators of geological carbon storage. Mr. Bengal in his testimony will make clear why states are well-suited experientially for this role by virtue of their technical expertise regulating oil and natural gas development and ancillary activities, including natural gas storage, acid gas injection and CO_2 enhanced oil recovery. Mr. Bengal will also explain how states, in most instances, are the administrators of the U.S. Environmental Protection Agency Underground Injection Control (UIC) Program. He will close by emphasizing the importance of public support of carbon storage as a strategy for mitigating the impact of global climate change. Key to this support will be public understanding the long history of CO_2 transportation, handling and use (including use to increase domestic oil production). Mr. Bengal will suggest that given the complexities of credits, ownership and usage of CO_2 that a new regulatory paradigm will be useful, one that is based on resource management rather than waste disposal.

Testimony

Good morning. My name is Lawrence Bengal. I am the Director of the Arkansas Oil and Gas Commission and I'm appearing today in my capacity as Chairman of the Interstate Oil and Gas Compact Commission's Task Force on Carbon Capture and Geologic Storage (CCGS). In the 5 years the Task Force has been in existence, its membership has been drawn from IOGCC member state and provincial oil and gas agencies, U.S. Department of Energy sponsored Regional Carbon Sequestration Partnerships, the Association of American State Geologists and industry. The Task Force has also had representatives from the U.S. Environmental Protection Agency (EPA), the U.S. Bureau of Land Management (BLM) and the environmental group Environmental Defense attending as observers.

The member states of the Interstate Oil and Gas Compact Commission (IOGCC) produce more than 99% of the oil and natural gas produced onshore in the United States. Formed by Governors in 1935, the IOGCC is a congressionally ratified interstate compact. The organization, the nation's leading advocate for conservation and wise development of domestic petroleum resources, includes 30 member states, 8 associate states, and 6 international affiliate provinces. The mission of the IOGCC is two-fold: to conserve our nation's oil and gas resources and to protect human health and the environment during the production process. Our current chairman is Governor Sarah Palin of Alaska.

The purpose of my testimony today is to share with the Committee the experience and conclusions of IOGCC's CCGS Task Force with regard to the geologic storage of carbon dioxide (CO_2). As this committee today explores the topic "Carbon Sequestration: Risks, Opportunities, and Protection of Drinking Water" I hope my testimony will demonstrate to the committee that states have a crucial and important role to play in the regulation of this most promising technology: the geologic storage of CO_2.

Let me begin by noting what may not be completely understood by everyone. In the United States, states are the primary regulators of oil and natural gas production and related activities including natural gas storage, acid gas injection and the injection of carbon dioxide (CO_2) for enhanced oil recovery (EOR). As that which must be regulated in the geologic storage of CO_2 is extremely similar to that which must be regulated in oil and gas production, states thus possess much of the knowledge base and skill sets that will be required of the on-the-ground regulator of CO_2

geologic storage. Additionally, one of the most important functions of the state in regulating oil and natural gas development and related activities is to ensure that in the construction and operation of the wells and ancillary facilities that the state's water resources are protected, including of course, groundwater. Additionally, states are already in most cases the ″on-the-ground″ implementers of the Underground Injection Control (UIC) Program of the U.S. Environmental Protection Agency (EPA) under primacy jurisdiction granted to states by the EPA.

It is also important to note that much of the state authority to regulate oil and natural gas production and related activities comes from the state's conservation code, which in most cases is based on the IOGCC Model Conservation Code. This means practically that the state codes are very similar to one another and that a company moving from one jurisdiction to another encounters far more legal and regulatory similarities than dissimilarities.

With the advent of the model laws and regulations created by the IOGCC Task Force and released by the IOGCC earlier this year, states now have a resource to begin to develop laws and regulations governing the regulation of carbon geologic storage. At present over 7 states are already well along in this process, having adopted or in the process of adopting such frameworks. This state-based regulatory system will incorporate, as the oil and natural gas regulatory regime does now, EPA requirements under the UIC program as expanded to include the storage of CO_2 along the lines announced by EPA last week. The Department of Transportation's Pipelines and Hazardous Materials Safety Administration (PHMSA) will also play a critical role in ensuring CO_2 pipeline safety. (The states also administer the PHMSA program as a federal-state partnership.) The result will be a combined state and federal regulatory system in the 2010-2011 timeframe that will provide a sound and nationally consistent regulatory framework for the geologic storage of CO_2 in the United States.

Let me now turn to a more detailed review of the Task Force history and its recommendations.

Funded by the U.S. Department of Energy (DOE) and its National Energy Technology Laboratory (NETL), the Task Force has been engaged since 2003 in a two-phase effort relating to the regulation of the geologic storage of carbon. In Phase I, the Task Force undertook a thorough review of the technology of geologic storage and in Phase II developed a model statute and model rules and regulations for the states and provinces to administer regulatory oversight of geologic storage of carbon dioxide (CO_2).

A major conclusion of the Task Force in Phase I was that the geologic storage of CO_2, in addition to conservation, is among the most immediate and viable strategies available for mitigating the release of CO_2 into the atmosphere. It was readily apparent to the Task Force that carbon storage was also not something entirely new and mysterious - but the technological outgrowth of four analogues. These four analogues, in the opinion of the Task Force, provide the technological and regulatory basis for storage of CO_2 in geologic media: 1) naturally occurring CO_2 contained in geologic reservoirs, including natural gas reservoirs; 2) the large number of projects where CO_2 has been injected into underground formations for Enhanced Oil Recovery (EOR) operations; 3) storage of natural gas in geologic reservoirs; and 4) injection of acid gas (a combination of H2S and CO_2), into underground formations, with its long history of safe operations.

It was the opinion of the Task Force that given the jurisdiction, experience, and expertise of the states and provinces in the regulation of oil and natural gas production as well in regulating the analogues identified above, the states and provinces would not only be well able to regulate, but would be the most logical and experienced on-the-ground regulators of CO_2 geologic storage. Additionally and importantly, the oil and natural gas producing states and provinces are strategically and geologically well-situated for the geologic storage of CO_2. Regulations already exist in most oil and natural gas producing states and provinces covering many of the same issues that will need to be addressed in the regulation of CO_2 geologic storage, and consequently serve as adaptable frameworks.

Given these Phase I conclusions, the Task Force, in Phase II, began work and in September of 2007 produced, for the first time, a clear and comprehensive model legal and regulatory regime for the geologic storage of CO_2. Utilizing these model regulatory frameworks, states and provinces, and indeed other nations, have the basic building blocks to begin immediately the process of developing and enacting legislation and promulgating rules and regulations enabling CO_2 geologic storage projects. Wyoming, Washington, Kansas, California, New Mexico, North Dakota, and Texas are, among other states, in various stages of developing such a legal and regulatory framework. Wyoming passed legislation this year relying heavily on the IOGCC model.

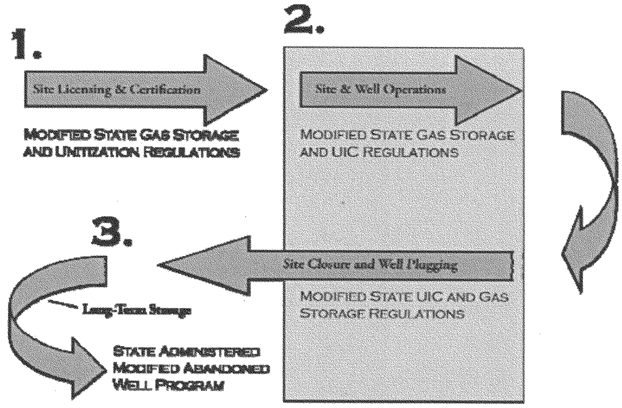
I anticipate that by 2010 there will be at least 7-15 states, encompassing much of the country best suited for carbon geologic storage, with legal and regulatory systems in place for the regulation of geologic storage of CO_2. The recently proposed EPA carbon storage regulations under the Safe Drinking Water Act and its implementing UIC program should also be in place by 2011.

Let me now briefly address how the IOGCC anticipates that the EPA's CO_2 geologic storage regulations will interface with the regulatory systems being developed by the states. Given the incorporation of UIC-like regulatory requirements into the proposed IOGCC model regulatory frameworks, there is every reason to anticipate that the IOGCC and EPA frameworks will fit like hand in glove. This is largely because of the role that states play in the administration of UIC programs under EPA state primacy authority.

As we've heard this morning, the EPA has been in the process of developing regulations for geologic sequestration under the Safe Drinking Water Act. Draft regulations were announced last week. The IOGCC at the invitation of EPA had two representatives, Berry ″Nick″ Tew of Alabama and myself, actively participating in the process as state co-regulators. States with primacy already play an integral role in administering the UIC program and under future rules governing geologic storage, are likely to do so again. Having representatives from states involved in the process helps insure compatibility between the state and federal components of geologic storage regulatory oversight.

What is clear to me, especially given my involvement with the current EPA workgroup, is that the state regulatory system for carbon storage proposed by the IOGCC Task Force will in all likelihood work seamlessly with the regulations likely to emerge out of the EPA regulatory development process.

It is now appropriate to supply a little more detail about the legal and regulatory system which the IOGCC Task Force has proposed for the geologic storage of CO_2 and how, precisely, the proposed EPA regulatory system for CO_2 storage would likely fit into this system. This diagram will be helpful:



The diagram represents the ″cradle to grave″ regulatory model which the Task Force has recommended to states. There are three phases.

1. LICENSING INCLUDING AMALGAMATION OF STORAGE RIGHTS

The first phase is the licensing phase which includes the critical requirement that the project operator control the storage rights.

The Task Force concluded that as a part of the initial licensing of a storage project that the operator of the project must control the reservoir and associated pore space to be used for CO_2 storage. The operator would need to acquire these rights from the owners or assume those rights by means of eminent domain, unitization or some other vehicle that either exists in a state or would be created by the state uniquely for this purpose. This step is necessary because in the U.S., the right to use reservoirs and associated pore space is considered a private property right and must be acquired from the owner. It was the conclusion of a Task Force legal subgroup that in most U.S. states, for non EOR-related storage, the owner of these rights would likely be the owner of the surface estate. It may be prudent, however, depending upon the specific property right ownership framework in a given state, for an operator to also control the relevant subsurface mineral rights.

Additionally, as part of the initial licensing of a project the operator would be required to submit for State Regulatory Authority (SRA) approval, detailed engineering and geological data along with a CO_2 injection plan that includes a description of mechanisms of geologic confinement that would prevent horizontal or vertical migration of CO_2 beyond the proposed storage reservoir. The operator would also be required to submit for approval by the SRA a public health and safety and emergency response plan, worker safety plan, corrosion monitoring and prevention plan and a facility and storage reservoir leak detection and monitoring plan.

The rules also include requirements for an operational bond that would be sufficient to cover all operational aspects of the storage facility excluding wells which would be separately bonded.

Site licensing and amalgamation of storage rights is generally believed to be outside the scope of the current UIC Program, and given that regulatory involvement with property rights is a state issue, this phase is best addressed at the state level. In addition, given the likely competition for acceptable storage sites, it is in a state's interest to manage these sites to maximize storage capacity and resolve any operator conflicts over the right to use storage resources, thereby maximizing the state's best economic interest in providing storage sites for that state's generators.

2. The Storage and Closure Phase

In this second phase we are talking about the phase, following initial licensing, when the storage project is developed, operated, and closed. This includes a short time period following plugging of the wells during which time the project is monitored to ensure stability of the injected CO_2.

During the storage component of this phase the model rules specify the procedures for permitting and operating the project injection wells to safeguard life, health, property and the environment. The operator would be required to post individual well bonds sufficient to cover well plugging and abandonment, CO_2 injection and/or subsurface observation well remediation. The rules also specify design standards to ensure that injection wells are constructed to prevent the migration of CO_2 into other than the intended injection zone. Provisions in the rules also ensure that all project operational standards and plans submitted during the licensing phase would be adhered to and that the project and wells are operated in accordance with all required operating parameters and procedures. Quarterly and annual reports would be required throughout the operational life of the project. The rules also ensure that the wells are properly plugged and the site restored. The individual well bonds, maintained during the operational phase of the project would be released as the wells are plugged.

The closure component of this phase is defined as that period of time when the plugging of the injection wells has been completed and continuing for a defined period of time (10 years unless otherwise designated by the State Regulatory Authority) after injection activities cease and the injections wells are plugged. During this closure period, the operator of the storage site would be responsible for providing the required data to ensure the injected CO_2 has not migrated beyond the project boundaries and the injected CO_2 plume has been stabilized. During this time the operator is required to maintain an overall project operational bond.

This phase is primarily where the EPA's proposed carbon storage rules will supplement state rules so as to ensure the operation and plugging of the wells are protective of the groundwater resources under the UIC Program.

3. Long-Term ″Care Taker″ Phase (long-term monitoring and liability)

This last phase is the Long Term or Post-Closure Period and is characterized as that period of time when the operator of the project is no longer the responsible party and the long-term ″care taker″ role is assumed by a government entity or government-administered entity. The major issue faced by the Task Force was how to deal with long-term monitoring and liability issues. The formula settled upon by the Task Force is the following:

At the conclusion of the Closure Period, the operational bond would be released and the regulatory liability for ensuring that the site remains a secure storage site would transfer to a trust fund administered by the state. During the Post-Closure Period, the financial resources necessary for the state or a state-contracted entity to engage in future monitoring, verification, and remediation activities would be provided by this state-administered trust fund.

The Task Force concluded that such a state-administered trust fund would be the most effective and responsive ″care-taker″ to provide the necessary oversight during the Post-Closure Period. The trust fund would be funded by an injection fee assessed to the site operator and calculated on a per-ton basis.

In summary, the EPA Regulations under the SDWA and the UIC Program will primarily deal with the Storage and Closure Phase as illustrated by the green box in the diagram, for it is only in the project areas within that box that EPA has authority under the SDWA. In addition to EPA's mandate to protect drinking water under the SDWA, the IOGCC regulations cover other public health and safety issues that need to be a part of a comprehensive regulatory framework. As previously stated, almost all of the well operational standards proposed in the IOGCC model regulations are already UIC requirements of one form or another.

What I anticipate is that the proposed EPA regulations, whatever they end up being, will yield a set of uniform national standards, which superimposed on whatever state regulations may be in place will result in national consistency of application so as to ensure that drinking water resources are protected. Again as previously stated, given most states (those with primacy) already administer the existing UIC program, they will continue to do so, conforming their state regulations as they pertain to the geologic storage of carbon to the minimum standard set by the new EPA regulations.

Unless the EPA regulations end up being unnecessarily proscriptive and onerous, the systems should work together perfectly and as I've already stated, ″seamlessly″. Certainly this is the hope and current full expectation of the IOGCC.

I will note that with regard to federal lands (surface and/or mineral interests), that federal regulations emanating out of the BLM will undoubtedly be necessary. However, what emanates out of BLM would in all likelihood be more akin to what the states have done with regard to state and private lands rather than an overarching and broader national regulatory scheme.

Additionally, our model regulatory system does not address the regulatory issues involving CO_2 emissions trading and accreditation for the purpose of securing carbon credits. The Task Force concluded that the issue of CO_2 emissions trading and accreditation would likely best be addressed in the marketplace and/or at the federal government level and was beyond the scope of the Task Force's mandate. In any event, the Task Force strongly believes that development of any future CO_2 emissions trading and accreditation regulatory frameworks should utilize the experiences of the states.

As concerns long term ″care taker″ liability, what the Task Force has proposed will have to be addressed by each state and province as they develop their own framework. It remains to be seen if states will agree with the Task Force or propose something new. There may indeed be a need for a federal role here at some point in the future but it is suggested that federal action in this area await a clear need manifesting itself in the years ahead.

Additionally and very importantly, states and provinces are likely to continue to regard CO_2 geologic storage reservoirs as a valuable resource that should be managed using resource management frameworks, therefore avoiding the treatment of CO_2 storage as waste disposal. In this context, the Task Force believes that CO_2 should not be classified as a hazardous substance or pollutant under existing regulatory frameworks. Given the complexities of credits, ownership and usage of CO_2, a new regulatory paradigm is needed based on resource management rather that waste disposal. The Task Force strongly believes that treatment of CO_2 as a waste under waste management regulatory frameworks will diminish significantly the potential of carbon storage technology to meaningfully mitigate the impact of CO_2 emissions on the global climate. The energy consuming public and the industry which produces that energy share a common goal in coming up with a workable solution.

Let me close by noting the obvious -- that public support for carbon storage as a strategy for mitigating the impact of global climate change will be crucial. It will be important to educate the public about this technology including CO_2's long history of being transported, handled, and used in a variety of applications. As such it will also be vitally important to include the public in every step of the regulatory development process, state and federal. State open meeting laws will ensure public notice and participation in the state process at both the legislative and regulation development stages.

Thank you for the opportunity to appear here today. If I can provide any additional information, please do not hesitate to ask. I would also ask that a copy of the full IOGCC Task Force Report be included in the record today.

Mr. GREEN. If you would submit that, I appreciate it—with your testimony. We have a series of votes in about 10 minutes. It will probably last the better part of 30 to 35 minutes, so if each of you

could summarize your testimony and we will be back for the questions as possible. Mr. Broussard, again, welcome.

STATEMENT OF DON BROUSSARD, WATER OPERATIONS MANAGER, LAFAYETTE UTILITIES SERVICES

Mr. BROUSSARD. Good morning. My name is Don Broussard, and I am the Water Operations Manager for the Lafayette Utilities System in Lafayette Louisiana. Lafayette Utilities System is an electric utility, a drinking water utility, a waste water utility and a telecommunications wholesaler. We serve a retail and wholesale population of approximately 170,000 people. Now, it is important to know that part of our electric generation does come from coal-fired electric generation units. I am appearing here today on behalf of the American Water Works Association, AWWA. AWWA is the world's oldest and largest association dedicated to safe water. Our utility members serve safe and affordable drinking water to more than 80 percent of the American people. We appreciate the opportunity to provide our views on geologic carbon sequestration this morning. Our overarching concern regarding geologic carbon sequestration is the potential contamination of underground sources of drinking water and the potential for other unintended and possibly harmful consequences. Water chemistry in an underground setting is complex and AWWA has several technical concerns regarding the potential for carbon sequestration to contaminate the USDWs.

Preventing degradation of water should not just be limited to contaminates with established maximum contaminate levels, but should also include other constituents whose presence may either make ground water more difficult to treat or impact the beneficial uses of that groundwater. Several references on geologic carbon sequestration discuss changes in the carbonate cycle, resulting in lower ph conditions and the release of iron, manganese, arsenic and possibly other inorganics into groundwater surrounding the injection zone. We need appropriate subsurface monitoring technologies identified and developed to prevent or respond to potential contamination of USDWs by these inorganic compounds.

The construction of the injection wells is a critical issue to AWWA, both in terms of the materials used and the depth of injection. Since the injection wells will be encased in cement, the long-term integrity of the cements that will be used during construction will need to be extensively tested under real-world conditions.

It is important to note that as the injection wells are constructed, they will be penetrating existing underground sources of drinking water and essentially be permanently living in the underground source of drinking water.

I might mention that one term that I have not heard mentioned today is a sole-source aquifer, where we have a drinking water source that has been designated as a sole-source aquifer it is impractical for a water utility to identify another source of groundwater or source of drinking water. So I just ask for particular consideration for those sole-source aquifers.

Another area of concern is often the lack of good records of abandoned wells that tapped the very same strata used for carbon dioxide sequestration. There is a presumption that even States with oil

and gas or mining operations have excellent up-to-date reports and have maps indicating abandoned wells and mines. That may not be the case.

Many States with extractive industries do have maps and surveys, but they are not sufficiently precise for geologic sequestration. Studies have shown that injected carbon dioxide has been pretty good at finding these abandoned wells and these wells allow for the transmission of carbon dioxide out of the confined aquifer into potential USDWs, and then eventually to the surface.

AWWA would like to see the issue of long-term liability resolved. EPA's proposed geologic carbon sequestration rule cannot address financial responsibility of the sequestration site after the formal period of post-injection site care has ended. We call on Congress to develop legislation that will address the issue of who has to assume financial responsibility of the site after the site closure requirements have been fulfilled.

Research on the geologic sequestration of carbon dioxide should take a holistic approach, encompassing a review of potential impacts on the current and future underground sources of drinking water. AWWA recommends that commercial scale carbon sequestration not be deployed until the results of current large-scale Department of Energy pilot projects have been received and reviewed. By waiting for these results, both the EPA and the Department of Energy will be better able to fully understand the effects of carbon sequestration on underground sources of drinking water. Then any necessary modifications can be made to the regs and sequestration technology before companies invest in processes that may have severe and potentially unintended consequences.

We are concerned that the results of current research and pilot projects may not be available until after EPA's regulation on geologic carbon sequestration have already been finalized.

In conclusion, AWWA is concerned that the proposed large-scale sequestration of carbon dioxide and underground aquifers may have significant impacts on the public, the environment and drinking water utilities. We are aware of the impacts that climate change will have on the water utilities across the country and recognize that something needs to be done to address climate change. We also recognize the need to have energy and that all fuel types, including coal, are essential. However, AWWA urges caution in moving forward with this technology. Thank you for your time and I would be happy to respond to any questions you might have.

[The prepared statement of Mr. Broussard follows:]

American Water Works Association

The Authoritative Resource on Safe Water SM

Statement

of Don Broussard, Lafayette, La. Utilities System

before the

House Subcommittee

on Environment and Hazardous Materials

on

Geologic Carbon Sequestration

July 24, 2008

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Statement
of Don Broussard, Lafayette, La. Utilities System
before the
House Subcommittee on Environment and Hazardous Materials
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Geologic Carbon Sequestration

July 24, 2008

Good morning. My name is Don Broussard and I am the Water Operations Manager for the Lafayette Utilities System in Lafayette, Louisiana. Lafayette Utilities System is an electric generation, transmission and distribution utility; a water production, treatment and distribution utility; a wastewater collection and treatment utility; and a telecommunications wholesaler. The utility serves a retail and wholesale population of approximately 170,000 and part of our electric generation comes from coal-fired generation units.

I am appearing here today on behalf of the American Water Works Association (AWWA). AWWA is the world's oldest and largest association dedicated to safe water. Our utility members serve safe and affordable drinking water to more than 80 percent of the American people. AWWA represents over 4,700 water utilities that produce approximately 80% of the drinking water in the United States. We appreciate the opportunity to provide our views on geologic carbon sequestration this morning.

While I am speaking for AWWA, I am reminded of the intrinsic relationship between serving water utility customers and electric utility customers. As is often the case with municipal utilities, our utility serves both electricity and water customers. Many cities anticipate significant sustained increase in water and electricity demands as populations increase. Water and energy efficiency and renewable energy, although important, alone won't suffice to meet these increased demands.

I. Overview

Our overarching concern regarding geologic carbon sequestration is the potential contamination of underground sources of drinking water (USDW) from such activities and the potential for other unintended, and possibly harmful, consequences. AWWA is particularly concerned about the potential for contamination of sole source aquifers and suggests that these aquifers be provided with special protective measures. An aquifer receives the designation of "sole source aquifer" if it is located in an area where there are few or no alternative sources to the ground water resource, and where if contamination occurred, using an alternative source would be extremely expensive.

AWWA urges caution on the implementation of large-scale, commercial geologic carbon sequestration, as little data are available regarding the potential effects of this technology on drinking water resources. While several federal agencies and non-

governmental entities are conducting research on this topic, the data from this research will not be available for several years.

We understand the need to support states in ongoing permitting issues, but AWWA recommends that commercial-scale carbon sequestration not be deployed until the results of the large-scale Department of Energy pilot projects have been received and reviewed. By waiting for these results, both the Environmental Protection Agency and the Department of Energy will be better able to fully understand the effects of carbon sequestration on USDWs. Then any necessary modifications can be made to the regulations and sequestration technology before companies invest in processes that may have severe and unintended consequences.

II. Contamination Concerns

AWWA has several technical concerns regarding the geological carbon sequestration program and the potential impact of carbon sequestration on USDWs. Our biggest concern is the prevention of degradation of USDWs. Protection of USDWs should be a key priority of any carbon sequestration program, and the focus of the current program appears to be commercialization of the technology. Preventing degradation should not just be limited to contaminants with established Maximum Contaminant Levels (MCLs), but should also include other constituents whose presence may either make groundwater more difficult to treat or impact the beneficial uses of that groundwater.

Water chemistry in an underground setting is complex. Several references on geologic carbon sequestration discuss changes in the carbonate cycle, resulting in lowered pH conditions and the release of iron, manganese, arsenic, and possibly other inorganics into groundwater surrounding the injection zone. These reactions, and others, may occur in other USDW zones if they are contaminated by carbon dioxide. Additionally, silica and boron, depending on aquifer composition, can dissolve into the groundwater. Silica is often a major concern for industrial applications and has also been found to interfere with adsorption processes used in drinking water treatment, such as arsenic removal. The impact of carbon dioxide injection on the mobilization and migration of these previously immobile species due to the changes in water chemistry (e.g., pH) brought about by the introduction of carbon dioxide should be extensively explored. We need appropriate subsurface monitoring technologies identified and developed to prevent or respond to potential contamination of USDWs by these inorganic compounds.

AWWA has concerns regarding aquifers and their potential contamination due to the acidic nature of carbon dioxide in either a gas or supercritical liquid state, and the impact that it may have on surrounding strata. Without neutralization, there is the possibility that the carbon dioxide could change the equilibrium state for the sediments within those strata. Also, while the gas would be well below existing groundwater aquifers that are of greatest importance, the long-term potential for that gas to pocket or find fissures in the confining layer is a significant concern.

AWWA is concerned about the potential for contamination of USDWs due to the presence of other compounds, such as nitrogen, carbon monoxide, sulfur dioxide, hydrogen sulfide, and possibly mercury, in the carbon dioxide injection stream. The purity of the injection stream is expected to vary by project for many reasons including different facility operating conditions, coal compositions and in-place pollution removal technologies. Plant operators should be encouraged to remove as many pollutants as is technologically feasible from the injection stream, with the goal of preventing the introduction of compounds that could possibly contaminate USDWs. As was suggested with carbon dioxide, preventing degradation of USDWs by these compounds should be a key priority during the implementation of carbon sequestration technology.

III. Construction Concerns

The construction of the injection wells is a critical issue to AWWA, both in terms of the materials used and the depth of injection. Since the injection wells will be encased in cement, the long term integrity of the cements that will be used during construction will need to be extensively tested under real-world conditions. It is important to note that as the injection wells are constructed, they will be penetrating existing USDWs and essentially be permanently "living" in the USDWs. As a result, there is the potential for adverse impacts to the USDWs through the operation of the carbon dioxide injection well. Also, it is unclear whether EPA and DOE will restrict injection to depths below which carbon dioxide would be a supercritical fluid or whether those agencies would allow injections into formations where carbon dioxide would be a gas. More research is

needed on these topics to fully understand the potential impact that these things could have on USDWs.

IV. Future Needs for Underground Storage

As the demand for water increases during the upcoming century and changes in climate impact traditional water supplies, water utilities will look for new sources of drinking water. It is likely that, as a result of these changes, there will be a greater reliance on groundwater through both new supplies and conjunctive use. The possibility exists that utilities might want to use some of these injection site aquifers as new potable sources. In fact, in several communities across the country, waters that were previously considered to be unusable, due to a salinity that was above 10,000 TDS, are now being used as drinking water sources. Using desalination technology, the water sources are treated to EPA's drinking water standards and provided to water utility customers. As desalination technology improves, even more saline water may be used in the future. Therefore, AWWA suggests that the selection standards for potential injection aquifers, and for USDWs, be reviewed and revised to prevent contamination of aquifers that might be considered viable USDWs in the near future.

While AWWA has not yet performed an exhaustive study of the impact of carbon sequestration on current or future water supplies, we are concerned that neither the state of the science nor the existing regulations are sufficiently developed to where carbon sequestration can seriously be considered as a greenhouse gas mitigation

technique. History has shown that many of the previously mentioned issues still need to be addressed and, for some of these issues, no acceptable resolution mechanisms are currently available.

For example, there are potential project sites for which there are no good records of abandoned wells that tap the very same strata used for carbon dioxide sequestration. There is a presumption that even states with oil and gas or mining operations have excellent and current reports and maps indicating abandoned wells and mines. This is not the case. Many states with extractive industries do have maps and surveys which are not sufficiently precise for geologic sequestration. Generally speaking, these are states with extractive industries such as mining or oil and gas, such as my home state. Other states have antiquated data or virtually *no data* to indicate the presence of very old abandoned wells or mines. Studies have shown that injected carbon dioxide has been pretty good at finding these abandoned wells and these wells allow for the transmission of the carbon dioxide out of the confined aquifer, into potential USDWs, and then eventually to the surface. Some of these abandoned wells or mines might be more than 100 years old. This information on wells and mines is essential to prevent inadvertent cross contamination and release of briny water and/or other contaminants into drinking water systems (USDWs). Obtaining that data will be expensive and take considerable time.

The injection of carbon dioxide into deep saline aquifers causes a shift in the subsurface pressure gradients surrounding the injection site. This can cause saline aquifers

located close to the carbon dioxide plume to be displaced into existing USDWs, contaminating the freshwater aquifer and rendering it unusable as a drinking water resource. There is also the potential for USDWs to be displaced in both the horizontal and vertical directions due to changes in subsurface pressures. Water rights issues may be raised if a USDW is displaced, as a utility may be planning to utilize a USDW, but suddenly finds out that it can not, as the USDW has been displaced into an area where another utility has jurisdiction. Also, as many of the saline aquifers transverse state boundaries, AWWA imagines there may be significant permitting questions raised for a saline aquifer that exists to two different states. We anticipate that either Congress or EPA will have to issue guidance on which state is the correct permitting authority for a geologic carbon sequestration project when the receiving geologic formation crosses state boundaries. This would be particularly important since so many underground formations cross state boundaries. AWWA notes that the proposed rule by EPA opted to not address geologic formations that cross state boundaries.

It should be noted that groundwater storage of water resources may become a favorable adaptation strategy for water management under climate change. This could be especially true for areas in the United States that will lose storage (e.g. decreasing snowpack) and/or require more storage (e.g. increasing population). Groundwater storage may be a better option than surface water storage options such as dams, which are prone to high costs, environmental opposition, and potentially higher evaporation rates under climate change. As such, this bolsters AWWA's concern regarding the unintended consequences of geologic carbon sequestration. In addition, any permitting

for geologic carbon sequestration should include an evaluation of the long-term need for the geologic area to serve as groundwater storage.

Finally, AWWA would like to see the issue of long-term liability resolved. EPA's proposed geologic carbon sequestration rule cannot address financial responsibility of the sequestration site after the formal period of post-injection site care has ended (default of 50 year length). Since EPA does not have the power to assign responsibility after this period of time has expired, we call on Congress to develop legislation that will address the issue of who has to assume financial responsibility of the sequestration site after the site closure requirements have been fulfilled. AWWA anticipates that this legislation would provide for a means by which drinking water utilities could recover any costs incurred as a result of USDW contamination by geologic carbon sequestration activities. Examples of potential costs include the installation of advanced water treatment technologies and/or development of alternative water sources.

V. Research Needs

As AWWA supports basing regulations on good science, we suggest that research be performed that addresses the potential unintended consequences on drinking water sources of emerging environmental technologies such as biofuels and carbon sequestration. Research on the geologic sequestration of carbon dioxide should take a holistic approach, encompassing a review of potential impacts on current and future underground sources of drinking water. AWWA estimates that the financial need for

research on climate change as it relates to drinking water utilities is on the order of $25,000,000 per year for a ten year period. This includes some smaller research projects on geologic carbon sequestration, however more funding would be required for the drinking water industry to perform large-scale research projects similar to those funded by the Department of Energy.

AWWA is aware of several ongoing research and pilot projects related to the geologic sequestration of carbon dioxide. However, we are concerned that the results of these projects may not be available until after EPA's regulation on geologic carbon sequestration has been finalized. AWWA believes that the results of this research are crucial to the development of a comprehensive regulation that protects water resources from the potential unintended consequences of geologic carbon sequestration. In particular, AWWA believes that research on the potential pathways for contamination of USDWs has not yet been completed. As a result, we are concerned that the appropriate subsurface monitoring methods and technologies have not been adequately identified or developed. AWWA believes that more detailed research is needed to identify the specific requirements for subsurface monitoring that can protect USDWs from contamination due to geologic carbon sequestration.

The proposed scale of carbon sequestration is unprecedented compared with traditional enhanced oil and gas recovery, increasing the potential for unintended consequences. As such, AWWA recommends that DOE and EPA include the drinking water utilities that are directly impacted by the carbon sequestration pilot projects as stakeholders.

Potentially impacted utilities must be involved in the development of appropriate aquifer monitoring programs for the pilot programs to appropriately ensure that the water resources are not adversely affected. This will allow the utilities to gain first hand experience regarding how the sequestration process will be implemented.

AWWA believes that other geo-engineering options need to be considered if certain geologic carbon sequestration is not an option in certain regional or state geologic formations either due to risks to USDWs or unacceptable geologic characteristics. AWWA does not believe we should put all our eggs in the geologic sequestration basket. AWWA does not profess to be an expert on these techniques but is aware of the research into the use of algae, bacteria and other geo-engineering methods to destroy or immobilize CO_2. It is possible that these might be preferable to geologic carbon sequestration in some locations.

VI. Conclusion

In conclusion, AWWA is concerned that the proposed large-scale sequestration of carbon dioxide in underground aquifers may have significant impacts on the public, the environment, and drinking water utilities. We believe that the drinking water community has a responsibility to advocate for stewardship of the USDWs and that the most responsible action for us at this time is to voice our concerns on geologic carbon sequestration. We are very much aware of the impacts that climate change will have on water utilities across the county and recognize that something needs to be done to

address climate change. We also recognize the need to have energy, and that all fuel types, including coal, are essential. If geologic carbon sequestration does not prove to be the most optimal method for dealing with carbon dioxide we are indeed in a difficult position as a country. While we acknowledge that geologic carbon sequestration has been identified as a means to combat climate change, AWWA urges caution in moving forward with this technology.

AWWA recognizes that at this point in time, geologic carbon sequestration is not particularly energy efficient as the collection, handling and injection of carbon dioxide is very energy and water intensive. We have heard it mentioned that the entire geologic carbon sequestration process results in a 30% parasitic energy load on the power plant, and that the water consumption could be two to four times greater. We are concerned about the cumulative energy and water footprint involved in this process and wonder if a net power gain is still realized when the extra consumption of water and power is included in the evaluation.

We recommend that commercial-scale geologic carbon sequestration technology not be deployed until the results of the large-scale DOE pilot projects have been received and reviewed, which will provide EPA and DOE a better understanding of the effects of carbon sequestration on USDWs. This will allow EPA and DOE time to adapt regulations and technologies to prevent adverse and unintended consequences to USDWs. Until the time when this technology is sufficiently developed, AWWA encourages EPA and DOE to engage in the following activities:

- Study and use of green/non-GHG power to eliminate carbon footprints;
- Implementation and support of water and energy conservation programs; and,
- Improvement of programs dedicated to encouraging increased power and water efficiencies on the industrial, residential and municipal fronts;
- Study other geo-engineering approaches to carbon dioxide destruction or immobilization.

Thank you for your time and I would be happy to respond to any questions.

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Summary of Statement
of Don Broussard, Lafayette, La. Utilities System
before the
House Subcommittee on Environment and Hazardous Materials
on
Geologic Carbon Sequestration
July 24, 2008

- I am Don Broussard, the Water Operations Manager for Lafayette, La., Utilities System.

- Lafayette Utilities System is an electric generation, transmission and distribution utility; a water production, treatment and distribution utility; a wastewater collection and treatment utility; and a telecommunications wholesaler.

- I am appearing here today on behalf of the American Water Works Association (AWWA), the world's oldest and largest association dedicated to safe water.

- Our overarching concern regarding geologic carbon sequestration is the potential contamination of underground sources of drinking water (USDW) and the potential for other unintended, and possibly harmful, consequences.

- AWWA is particularly concerned about the potential for contamination of sole source aquifers and suggests that these aquifers be provided with special protective measures.

- Water chemistry in an underground setting is complex; we need to consider how geologic carbon sequestration could change the carbonate cycle, resulting in lowered pH conditions, and the potential release of iron, manganese, arsenic, and possibly other inorganics into groundwater surrounding the injection zone.

- We recommend that commercial-scale geologic carbon sequestration technology not be deployed until the results of the large-scale DOE pilot projects have been received and reviewed, which will provide EPA and DOE a better understanding of the effects of carbon sequestration on USDWs.

- AWWA would like to see the issue of long-term liability resolved.

- The construction of the injection wells is a critical issue to AWWA, both in terms of the materials used and the depth of injection.

- As the demand for water increases and changes in climate impact traditional water supplies, water utilities will look for new sources of drinking water...there will likely be a greater reliance on groundwater and the possibility exists that utilities might want to use some of these injection-site aquifers as new potable sources.

Mr. GREEN. Dr. Duncan.

STATEMENT OF IAN DUNCAN, ASSOCIATE DIRECTOR, EARTH AND ENVIRONMENTAL SYSTEMS, BUREAU OF ECONOMIC GEOLOGY

Mr. DUNCAN. Thank you Mr. Chairman. My name is Ian Duncan. I have a Ph.D. in geological sciences and I am the Associate Director of the Bureau of Economic Geology at the University of Texas, which is the second largest research institute at the University. I also believe—I normally don't make statements like this because it is too much of a Texas thing, but I believe the University of Texas has the largest group of researchers working in geological sequestration in the country.

Based on all the available information to me, I believe that large-scale CO_2 sequestration in deep brine reservoirs can be done safely and effectively and without endangering the country's drinking water resources. My basis for saying this is, in part, on the 35 years of experience that we have in Texas in the Permian Basin of injection of CO_2. Also, on the natural occurrences of CO_2, where we can show that naturally generated carbon dioxide has been contained by seals, the same kind of seals that we would propose to use for sequestration on the time scale of millions of years.

Based on my review of the recent EPA draft regulation documents, I commend the EPA for the quality and comprehensiveness of their draft. I think they have done excellent work in trying to include stakeholder input into this. I think it is an excellent start and I will look forward to having further input on their development of the rule.

I do have a concern that the EPA does not have a legislative mandate to require, encourage or even suggest that operators choose the most optimal—by optimal I mean lowest risk leakage site available. And myself and my co-author J.P. Nicot have written a paper suggesting a mechanism by which this might occur, and this is detailed in my written testimony.

It is critical that EPA be given sufficient resources to develop, implement and enforce the regulations, also that State agencies be. This is a new kind of process that is involved in carbon sequestration. It is going to require well-trained technical people to enforce it. I believe that performance standard based approaches to regulating CO_2's sequestration offer considerable advantages over prescriptive approaches. They are flexible and they can do what we call learn-as-you-go, in other words the first big projects that come in, we are going to learn from them and we need regulations that can adapt from them. Again, my written testimony details some aspects of the performance standard approach and gives an example with respect to seals.

In the near term, CO_2 enhanced oil recovery combined with appropriate monitoring mitigation and verification can make a significant contribution to putting man-made CO_2 into permanent storage and depleted oil reservoirs. And it may have been a little confusing in some of the previous testimony where it was, perhaps, suggested that CO_2 involved in enhanced oil recovery is just there to recover the oil.

I refer to my written testimony again, but in the Sacroc oil field in Scurry County, Texas, Kinder Morgan is currently injecting 30.5 million tons of CO_2 a year. Seven million tons of that is being recycled, stripped out of the oil and re-injected, and 6 and a half million tons is being permanently stored as near as we can tell. That makes it, by far, the largest sequestration project, and I use that term loosely, not specifically because it is not being monitored. It is not anthrogetic, but it shows the potential.

I also agree with the members of the committee who suggested we have not taken enough advantage of the CO_2 enhanced oil recovery as a resource to learn from. The Bureau of Economic Geology has one small project going at Sacroc trying to detect any leakage and so far we haven't found it, but I think it would be a good use of resources to put more money into research related to CO_2 enhanced oil recovery and also to use it as a natural laboratory.

Now, I want to make a self-serving statement. The Congress should appropriate funds to support University research in CO_2 sequestration, outside the partnership program and also in CO_2 enhanced oil recovery. Congress cut the funds for studying oil and gas research and the reason I suggest you should do this is that when I go to carbon sequestration conferences, I discover I am one of the youngest people there and I am, like, 58. We have a crisis in having the people power to be able to do this. Thank you.

[The prepared statement of Mr. Duncan follows:]

STATEMENT OF IAN DUNCAN

My name is Ian Duncan. I have a PhD in Geological Sciences and I am an Associate Director of the Bureau of Economic Geology (BEG) at the University of Texas at Austin. The University of Texas has arguably the largest group of researchers in the country focused on CO_2 sequestration in deep brine reservoirs. The BEG is engaged in research in a broad range of energy related and environmental issues including CO_2 sequestration. The BEG's Gulf Coast Carbon Center (GCCC) is an industry-academic-NGO collaboration working on geologic CO_2 sequestration including Enhanced Oil Recovery CO_2 EOR.

The GCCC's Frio Pilot Injection Project, led by the BEG's Dr Susan Hovorka and funded by the DOE's National Energy Technology Laboratory, was the first highly instrumented CO_2 injection experiments in the world. The Frio Brine Pilot Injection project (conducted 2004 to 2007) was:

•A first-of-a-kind field investigations into the viability injecting CO_2 into a brine-filled sandstone reservoir for long term geologic storage or sequestration; and

•A carefully monitored, small-volume (1,600 tons), short-duration experiments using injection of CO_2 into high-permeability brine-bearing sandstone to test the effectiveness of computer modeling and various monitoring techniques.

The Frio Brine Pilot project was designed to begin to develop the understanding necessary to begun large scale CO_2 injection. No evidence has been found of CO_2 leaking or behaving in any way not predicted by pre-injection computer simulations. Extensive monitoring has not detected any evidence of leakage of the geologic reservoir. The Frio Pilot Injection has shown that relatively low-cost, off-the-shelf, monitoring techniques can provide cost effective monitoring of CO_2 injections for sequestration. This project has also confirmed the utility of computer simulations to accurately model the fate of CO_2 injected into subsurface brine reservoirs.

The GCCC currently has a significant field-test of CO_2 sequestration in brine reservoirs underway in Mississippi (Denbury resources Cranfield CO_2-EOR site). This field test seeks to show the effectiveness of CO_2 sequestration, and how we can best predict and document the long term retention of CO_2 through modeling and monitoring. These studies are funded by about $50 million in Department of Energy funds (over 10 years).

For the past nearly four years I have been doing research on the role that CO_2 sequestration in deep brine reservoirs and associated with CO_2 enhanced oil recovery (CO_2-EOR) can play in mitigating greenhouse gases in the atmosphere and in

increasing domestic oil production in the US. Recently I have been working on developing a regulatory framework for CO_2 sequestration in brine based on performance standards rather than prescriptive standards (command and control).

The key points that I would like to make are:

(1) Based on all the available information I believe that large scale CO_2 sequestration in deep brine reservoirs can be done safely and effectively without endangering the nation's underground sources of drinking water (USDW).

(2) Based on my review of the recent EPA draft regulatory documents, I commend the EPA for its quality and comprehensiveness. I compliment the EPA staff on their efforts to foster broad stakeholder input into their process.

(3) I will not be making specific comments on the details of the EPA draft as I do not want to preempt the mechanism for stakeholder comment that the EPA has in place.

(4) I have a concern that the EPA does not have any legislative mandate to require, encourage or even suggest that operators choose the most optimal (lowest risk of leakage) sites available.

(5) It is critical that EPA be given sufficient resources (including trained professional staff engineers and scientists) to fully develop, implement, and enforce regulations for carbon sequestration.

(6) Performance standard based approaches to regulating CO_2 sequestration offer considerable advantages over prescriptive approaches.

(7) In the near term, CO_2-EOR combined with appropriate monitoring, mitigation, and verification, (MMV) can make a significant contribution to mitigating increases in CO_2 emissions by putting man-made CO_2 (CO_2-A) into permanent storage in depleted oil reservoirs.

(8) Congress should appropriate funds for the DOE to support university research into CO_2 sequestration associated with CO_2 EOR and for individual investigator research outside of the Sequestration Partnership program. Such funding would help produce young engineers and geologists trained in CO_2 related technologies and alleviate a shortage that is critical now and will grow more so in the near future.

DEVELOPING A SEQUESTRATION CAPABILITY IN THE US

CO_2 sequestration will involve the capture of anthropogenic CO_2 (typically from electric power plants) followed by deep subsurface injection into oil and gas reservoirs, deep unmineable coal beds or deep brine reservoirs. Approximately 80% of the CO_2 injection in the world today takes place in the Permian Basin of Texas and New Mexico, making the region the largest commercial market for CO_2. Texas corporations and technical workers have a unique experience base and outstanding safety record, in pipeline transport and subsurface injection of CO_2. Since the early 1970s, CO_2 has been injected into many Permian Basin oil reservoirs to enhance production. Injected CO_2 is dominantly produced from natural accumulations and pipelined to the Permian Basin. In addition, on the order of 10% is now derived from other sources such as gas processing plants where the CO_2 would otherwise have been released to the atmosphere. Currently roughly 30 million metric tons (MMt) of CO_2 are injected annually in the Permian Basin in operations that are closed-cycle. In other words, CO_2 that is produced from the oil reservoirs in association with the recovered oil is recycled (re-injected into the reservoir for additional recovery).

Many individual injection operations in the Permian Basin are at the scale of CO_2 production associated with coal burning power plants. CO_2-flooding for enhanced oil recovery (EOR) has been active at SACROC Oil Field in Scurry County since 1972. Kinder Morgan the current operator at SACROC currently injects 13.5 MMt CO_2/yr and withdraws/recycles 7 MMt CO_2/yr, for a net storage of 6.5 MMt CO_2/yr. For comparison, a 500 MW pulverized coal power plant produces roughly 3-4 MMt CO_2/yr. This magnitude of annual CO_2 storage at SACROC is over six times the rate of Statoil's Sleipner project offshore Norway.

The Gulf Coast has a large potential for CO_2 EOR outside of the traditional area of CO_2 EOR in the Permian Basin. Using miscibility screening criteria, BEG staff have inventoried 767 oil reservoirs where miscible CO_2 EOR could be applied for an additional 3.8 billion barrels of oil recovery. By way of comparison, annual oil production in USA is about 1.86 billion barrels. This incremental production target is attractive in terms of wellhead value, tax revenue, and economic activity. This EOR activity would lead to the use of large amounts of CO_2, however, it is small in the context of the projected 55 to 70 billion tons of CO_2 emissions for the Gulf Coast over the next 50 years. Deep brine reservoirs in the Gulf Coast have been estimated by BEG staff to have a sequestration capacity about 4 times this value (that is over 200 billion tons of CO_2).

EOR results in storage of CO_2 dissolved in residual oil, dissolved in brine, and trapped as an immobile supercritical phase. Experience in mature Permian basin CO_2-EOR projects is that 30 to over 60% of the injected CO_2 is retained in the reservoir over a year of injection (starting at 100% retention for the initial phase of the project). Due to recycling (capture and reinjection of CO_2 produced with the oil), it is likely that appropriate MMV techniques would demonstrate that in most instances 99% +/- .05% of the CO_2 used is ultimately sequestered in the oil field. However, the volume retained as a by-product of EOR is small relative to total point source emissions. The large synergy between EOR and reducing carbon emissions is that EOR would enable the construction of an infrastructure linking sources to reservoirs. Very large volumes of brine reservoirs can then be accessed beneath oil production, a concept that we describe as stacked storage. Existence of an infrastructure would reduce the cost of storage of Gulf Coast power plant, refinery, and chemical plant emissions for the next 50 years or more.

The Gulf Coast of the USA is a region of high CO_2 emissions that overlie thick, extensive, and well known subsurface geologic formations. The path forward toward developing an economically viable system for capture and storage includes: (1) development of a climate favoring construction of gasifiers using coal, lignite, petcoke and/or biomass as sources (IGCC electric power plants for example), (2) construction of a pipeline backbone to transport CO_2 regionally, (3) a market for CO_2 for EOR in areas beyond the traditional area of use in the Permian Basin, and (4) development of stacked storage, using deeper brine-bearing formations beneath hydrocarbon reservoirs.

Sequestration credits may play a significant role in future CO_2 EOR based on anthropogenic CO_2. The criteria to qualify projects for CO_2 credits are likely to evolve as the industry matures. A recent Texas law creating a tax credit for CO_2 EOR using anthropogenic CO_2 requires projects to establish a reasonable expectation that they can meet a performance standard of 99% retention for 1,000 years. To meet this standard, operators will likely have to: characterize the seal for their reservoir and demonstrate that it is compatible with this standard; design and implement an appropriate monitoring program and complete a CO_2 life cycle analysis to verify the amount of CO_2 avoided.

Up until now, CO_2 purchase has been the largest cost component of a CO_2-EOR flood. As a result engineers and geologists in companies and the Universities have developed and refined technologies and approaches to minimize CO_2 usage in CO_2-EOR projects. We may be entering a new regime in which CO_2 injection gains credits that will change the fundamental economics. Under these circumstances new or previously little-used approaches to CO_2 EOR projects such as vertical floods and CO_2 alternating with CO_2 foam may become viable. Such approaches offer great opportunities for increasing the total oil recovery and maximizing CO_2 storage. However research in combination with full scale field test will almost certainly be necessary to convince companies of the viability of these and other ″game changing″ technologies.

Although this testimony has focused on the Gulf Coast and Permian Basin of Texas, significant CO_2-EOR potential also exists in a number of other states including Louisiana, New Mexico, Oklahoma, Wyoming, Illinois, Michigan, California, Kansas, Mississippi, North Dakota, Montana and others. In the context of economic growth, global oil demand and atmospheric mitigation of CO_2, a 'first step' mechanism is required to sequester large volumes of CO_2 in EOR operations in a manner that later allows pure CO_2 storage to initially 'piggyback' via the commercial leverage of the oil recovered.

CO_2-EOR can create an effective bridge to CO_2 sequestration in brines, by providing the financial capacity and rationale for developing a CO_2 capture, compression and transportation infrastructure across a significant portion of the US that can later be used for large scale CO_2 sequestration in deep brine reservoirs. To facilitate this happening, Congress should provide a policy/regulatory environment that encourages CO_2-EOR operators to change business as usual by: a) utilizing CO_2-A when available at reasonable cost from capture at power plants; b) creating and implementing MMV plans to provide assurance of permanent sequestration; and c) conduct life cycle analyses of their projects to measure CO_2 avoided.

CREATING A NEW REGULATORY FRAMEWORK FOR CO_2 SEQUESTRATION

The two key aims of a regulatory framework for CO_2 injection should be: to ensure public health and safety; and to prevent environmental damage, particularly damage to drinking water resources. Additional issues that should be addressed by the regulatory process include:

•The concerns of local government and local residents. Any negative environmental consequences of geologic sequestration are likely to impact the local community

•Providing a mechanism for stakeholders and the general public to have effective input into the both the permitting process and the integrity of subsequent regulatory oversight.

•Supporting confidence of the market place for CO_2 sequestration credits by assuring transparency.

•Assuring adequacy of long term monitoring, mitigation and remediation efforts.

(A) ENCOURAGING OPTIMAL SITE SELECTION THROUGH CREATING A GENERAL PERMITTING PROCESS FOR SEQUESTRATION

An aim should be to require the selection of sites that have low risk of leakage. The Carbon Capture Project, an industry based research collaboration, has suggested that the first key to lowering the risks associated with CO_2 sequestration projects is ″careful site selection″. The long term risk of leakage of brine sequestration projects is very much dependant on site selection. Permitting is by its very nature a binary (yes or no) decision. Currently the EPA has no legislative mandate to encourage selection of the best sequestration targets.

One approach to encouraging companies to select the sites that are least likely to leak based on best available scientific knowledge is to implement the General Permit model of Nicot and Duncan 2008. In this paper we suggest that States, with guidance from Federal agencies (U.S. Geological Survey, U.S. EPA), should be responsible for developing regional evaluations of geology and engineering properties of potential brine reservoirs for CO_2 sequestration. Such studies could include regional static reservoir models, numerical models of the evolution of CO_2 plumes, and regional risk assessments. State and Federal governments should be proactive in starting regional studies with stakeholder (general public, local governments, operators, CO_2 generators) input that would rank areas according to criteria developed from such broad input. Rankings based on a systematic approach to risk assessment could be established with the help of decision-support tools specifically developed for this purpose. These ″risked-based″ or ″risk-informed″ approaches have already been used for other performance-based permitting systems developed by the U.S. EPA. The EPA has a long history of ranking sites with some degree of success. The DRASTIC program and Risk Based Corrective Action are two examples. Similar schemes could be used for carbon-storage sites.

As the permitting system evolves, it will be important to build in market-based incentives to encourage innovation and to reward sound stewardship. Such incentives could include streamlined permitting, extension of existing permits to encompass multiple injection projects into the same brine reservoir, and waiving of some requirements on the basis of an exemplary track record. Innovative permitting can lower overall cost of sequestration, at the same time encouraging technical innovation and improved performance.

A hierarchical approach to permitting could be developed. The first level, the general permit phase, would be based on regional assessments of specific brine reservoirs. A State agency responsible for the permitting process of geologic sequestration carries out regional-scale assessments for suitable target regions on the basis of sophisticated modeling and extended data sets. A national agency, such as U.S. EPA, could also be involved when UIC oversight responsibility has not been delegated to the State. National/Federal agencies could also help in or be required to providing consistency across lower-level entities (states, provinces, etc). Counties, metropolitan areas, and subregional agencies could carry out a subregional-scale assessment. The results will then be used by the designated State or Federal agency to create general permits for specific regions for individual and/or groups of brine reservoirs. Individual operators apply for permits (as in the case of deep injection wells).

For early-entry projects it likely will not be possible to implement the hierarchical approach without unnecessarily delaying initiation of geologic sequestration. For large scale implementation of sequestration EPA should be given a legislative mandate that enables it to regulate sequestration in a regional context rather than on a well by well or even project by project basis.

(B) PERFORMANCE STANDARD BASED APPROACHES TO REGULATION

To have a significant impact on decreasing the rate of increase of atmospheric CO_2 levels, geologic sequestration in deep brine reservoirs will have to occur on a very large scale. The scale of individual injection projects is likely to be as large as or larger than any previously permitted under the UIC program. In addition CO_2

is more buoyant (though less hazardous) than other fluids regulated by the UIC process. Performance standard based approaches are the best able to adapt to evolving understanding of the technologies involved. Additionally, a performance-based framework will increase the quantity and quality of information available to the public and other stakeholders.

The regulatory landscape can be viewed as a continuum between prescriptive and performance- based regulation. Prescriptive regulation is based on prescribed actions. In contrast, performance-based regulation sets goals for outcomes. The specific means to achieve the outcome is left up to the regulated entities. Perhaps inevitably particular regulatory frameworks have become associated with particular political parties or even philosophical movements within political parties.

New Zealand's Building Act of 1991 was the first to fully implement a performance-based regulatory regime across a whole industrial sector. This legislation represented a specific philosophy based on faith in market forces and minimal governmental interference to maximize efficiency. Part of these reforms allowed private certifiers to monitor compliance with desired performance goals. Unfortunately within a decade New Zealand newspapers were investigating what became known as the "leaky building crisis", caused by a pervasive failure of the regulatory approach. Over 18,000 houses were affected; many were determined to be uninhabitable.

The record of an official inquiry in 2002 into the crisis identified a number of problems including imprecise specification of performance standards as well as systemic deficiencies in accountability and enforcement. New Zealand's response to the leaky building crisis was the 2004 Building Act which created: increased accountability; introduced tighter specification of performance standards; stronger monitoring of inspection practices; and increased rigor for licensing of certifiers.

Based on review of the New Zealand experience the following recommendations can be made to strengthen performance standard based approaches to regulating CO_2 Sequestration:

Create performance standards that are as clear and specific as possible

Justice Breyer has noted that often performance standards are hard to enforce due to the difficulty of developing appropriate tests for adequacy of performance. Performance standards should be expressed in a quantitative form wherever possible. Clearly performance metrics that are expressed in well calibrated shades of grey (probabilistic) are to be preferred over binary black/white (or yes/no) measures.

Create hybrid regulatory frameworks that combine traditional specification based approaches (where this makes sense) with performance based approaches.

Some situations call for a ″hybrid approach″ that combines performance standards with prescriptive regulations. One approach is to add provisions for alternative compliance mechanisms. Such provisions can enables allow firms to 'opt-out' of prescriptive standards if they can get a comparable level of performance in other ways.

Develop clear and effective reporting requirements

If the required effort to implement the standards is unclear then this can increase the cost of compliance compared to prescriptive regulations. Where possible, for each permitted project, specific metrics should be developed for each performance standard. These metrics, once agreed on should become part of the permit.

Create strong professional accountability of regulatory staff and third party certifiers.

As was found in the ″leaky buildings crisis″ in New Zealand, performance based regulatory frameworks function as intended only if there is effective enforcement. Strong codes of practice for regulatory professionals and third party certifiers that encourage exercise of sound professional judgment should be required by Congress.

Maximize transparency by increasing information available to the public

Regulation determines levels of environmental quality through public processes. Increasing the amount and quality of information available to the public will improve the transparency of the regulatory process. Non-Government Organizations (NGOs) can play a very useful role in acting as surrogates for the local community in monitoring projects.

Create an environment that encourages proactive compliance by regulated entities

Incentives to reward sound stewardship could include ″fast track″ permitting; extension of permits to multiple injection projects in the same brine reservoir; and waiving of some requirements on the basis of an exemplary track record.

Develop accountability through performance audits

Strategies should include: (1) self audits by regulated entities themselves particularly when the self reporting is done by well trained, certified professionals; (2) independent audits by third party, certified professionals; (3) audits by a regulatory agency; and (4) review of audit results by independent oversight boards composed of experts in the field.

Build in ″learn-as-you-go″ into the regulatory framework as an ongoing adaptive approach to process improvement by systematically both tracking learning on multiple levels and achieving consensus on the key lessons learned.

The Carbon Capture Leadership Forum has suggested that a 'learn-as-you-go' strategy will be essential to implement sequestration in a timely manner. The ultimate expression of ″learn-as-you-go″ is a regulatory framework that accommodates adaptive evolution of the permitting process itself.

Proactively integrate computer modeling into the regulatory process to maintain both flexibility and accountability

The results of computer simulations will likely play a key role in both preparing and evaluating permit applications for large scale CO_2 injection projects.

(C) Can Performance Standards be developed for Regulating CO_2 Sequestration in Deep Brine Reservoirs?

Performance standards are objectives that the regulatory agency (representing the interests of society in general) place on regulated entities.

The FutureGen Alliance's Request for Proposals (RFP) for injection sites established a prescriptive standard for seals. The Alliance had specific requirements for an acceptable primary seal, stating that the seal ″must have sufficient thickness (greater than 20 feet [6 meters])″. Requiring a minimum thickness for a seal is an arbitrary prescription. A useful performance standard for an adequate seal is:

Performance standard 1. The operator must demonstrate that the reservoir has a top seal and other elements of a natural and engineered containment system with petrophysical and geological properties consistent with protection of underground sources of drinking water (USDW) from contamination from injected CO_2, pollutants mobilized by the CO_2 injection, and/or water high in total dissolved solids (TDS) set in motion by pressures induced by the injection.

Such a standard could be supported by more technical sub-standards such as:

Performance Standard 1a. An acceptable seal must have either a measured capillary entry pressure higher than the predicted maximum pressure at the base of the seal or a combination of permeability and thickness such that the seal effects a sufficient barrier to the flow of CO_2 under the conditions of the specific project such that the retention performance standard is assured. It is acceptable to document the effectiveness of the seal by analogy with the equivalent sealing unit elsewhere retaining natural gas or oil, assuming that enough information is known about each seal to consider them equivalent (in their permeability and capillary entry properties).

Whether or not performance standard based regulations are integrated into the EPA's approach to regulating CO_2 sequestration, I believe that the EPA will need significant additions to their professional staff to enable effective regulation. Regulating CO_2 sequestration will involve a wide range of scientific and engineering issues such as: geochemical interaction of rock, gas and brine; the geomechanical effects of high injection pressures; and evaluation of computer simulations of multiphase flow. All of these issues require well trained professionals to evaluate. Congress should make sure that the EPA has sufficient staff and resources to develop and enforce their regulatory framework for CO_2 sequestration.

EVALUATING THE RISKS ASSOCIATED WITH GEOLOGICAL CO_2 SEQUESTRATION

Based on the available information from over 35 years of CO_2 injection into geologic reservoirs in the Permian basin of Texas and on scientific knowledge from natural CO_2 reservoirs, I believe that large scale CO_2 sequestration can be done safely and effectively without endangering the nation's underground sources of drinking water (USDW). Although safety and health issues are always of paramount concern, the excellent safety and health record of the CO_2 industry in the Permian Basin of West Texas, and the absence of known negative impact on USDW suggest that these issues are not a major component of the business risk faced by a putative carbon sequestration industry. Having said this, it is very unfortunate that very little research funding is available to study and assess the wealth of potential information available from studying the results of the long term CO_2 injections in the Permian Basin by CO_2 EOR operators. Apart from a small DOE funded research project through the Southwest carbon Sequestration Partnership and led by the BEG, only very limited research is being done in this crucial area. I recommend that Congress should appropriate funds for the DOE to support university research into CO_2 sequestration associated with CO_2 EOR particularly in the Permian basin which has the longest history of CO_2 injection in the world. An aggressive research program including pilot projects would help improve the performance of current EOR activity and enable the development of new more effective approaches that could increase oil recovery, reduce the geological and technical risks, and enhance sequestration

rates incidental to CO_2-EOR. Such funding would also help produce young engineers and geologists trained in CO_2 related technologies and alleviate a shortage that is critical now and will grow more so in the near future.

It has recently been suggested that an effective system of regulation for geologic sequestration should share the long-term risks of sequestration between the public and private entities. I prefer to place the emphasis not on the government sharing the long term risk but rather on reducing risk of leakage by creating a regulatory framework that: (1) provides a mechanism to assure optimal site selection (2) minimizes risk by requiring adequate site characterization; (3) assures early detection of any leakage by insisting on deep monitoring; and (4) requires preventive action to lower the chance of leakage leading to adverse outcomes. Government resources should be deployed early in the project life cycle, focused on optimizing selection and evaluation of sites. Providing careful oversight of risk assessments and then requiring early and vigorous implementation of preventative action will be more valuable than reserving resources to remediate problems that could have been prevented.

In conclusion I am confident that we have the technical understanding, the scientific knowledge and the experience to implement CO_2 sequestration on a large scale in such a way that the nation's drinking water resources are effectively protected.

Mr. GREEN. Time. You are over time. I appreciate your comment on the appropriations—Mr. Anderson?

STATEMENT OF SCOTT ANDERSON, SENIOR POLICY ADVISOR, CLIMATE AND AIR PROGRAM, ENVIRONMENTAL DEFENSE FUND

Mr. ANDERSON. Scott Anderson with Environmental Defense Fund, thanks for letting me be here. At the outset I would like [microphone cuts out]—thank you—thus joining the lower cost methods of addressing climate change. We do not know what the next decades hold in terms of coal demand. Whether its share of the market will be up or be down, but we are convinced that coal will be around for a long time, that CCS is an essential technology and that as a technological matter, if not a commercial matter, that this technology is ready to begin deployment now in carefully selected and carefully managed sites. In fact, there are already special situations where CCS is beginning to be deployed, but in general deployment of CCS is held back by two main factors, a lack of inadequate price signal from the market and uncertainty about the regulatory framework. We believe it is within our grasp to solve both of these problems.

I would like to cover several things this morning. My main focus will be to suggest what regulatory elements are needed to manage the risks of geologic sequestration, particularly risks relating to drinking water, and to offer a preliminary assessment of the EPA rules. I would also like to comment, briefly, unless I run out of time on regional capacity assessments and offer a few observations on the liability issue.

As to the elements of inadequate regulatory system, we believe it should be reasonably flexible to account for different geologic environments and evolving understanding of particular sites, that it should be adaptive in the sense that requirement should become more sophisticated as knowledge improves and that it should tend to be performance based, although some aspects of the rules ought to be more prescriptive than others.

But being flexible and adaptive and performance based is not enough. It is also essential that regulations stay focused on assur-

ing that underground sources of drinking water are protected and this cannot be compromised. This focus includes rigorous standards relating to site characterization and selection, operations, adjustments to site characterization modeling and operations—I meant to say, based on experience, rigorous closure procedures, and very rigorous—this is the whole ball game—very rigorous standards for post-closure determinations that projects do not and will not endanger USDWs.

Turning to the proposed rules, we are happy to say that our preliminary assessment is positive. In particular, we support the new Class VI idea. We support the broad approach to finding the area of review. We, generally, support the extensive level of information that is being required of permit applicants. And this is a key one, we are glad to see that the agency is avoiding using the simple passage of time in order to conclude that there are no problems. That is an insufficient standard.

[The prepared statement of Mr. Anderson follows:]

Statement of Scott Anderson

We appreciate the opportunity to speak to you today as the Committee examines the regulatory framework necessary for carbon sequestration, particularly measures that need to be taken to protect underground sources of drinking water. We also appreciate the opportunity to make a few comments regarding capacity assessments for the sequestration of carbon dioxide in geological formations. Climate change is the most important environmental issue of our generation and successful development and deployment of geologic sequestration is a critical path for accommodating coal, the world's most abundant but carbon-intensive fossil fuel, to a carbon-constrained future.

Environmental Defense Fund (EDF) is a national non-profit organization representing more than 500,000 members. Since 1967, we have linked science, economics and law to create innovative, equitable and cost-effective solutions to urgent environmental problems. My personal background includes more than 20 years representing independent oil and gas producers in Texas, and so I have some appreciation for many of the issues and concerns related to the underground storage of carbon dioxide.

The House is doing important work to address the threat of climate change. The single most important thing the House can do to further the geologic sequestration of CO_2 is to take action on cap and trade legislation, since such legislation would create a market value and a market mechanism for avoiding carbon dioxide emissions. Given the right incentives, we believe that the market will be far more effective and efficient in discovering necessary technologies of all types, including carbon capture and storage (CCS), than any suite of government mandates or subsidies, however well intentioned.

Also vital is your interest in determining what regulatory measures are needed for geologic sequestration to satisfy the goals of the Safe Drinking Water Act. Without a sound regulatory framework, geologic sequestration of carbon dioxide could fail to live up to its promise and in fact lead to additional environmental problems. CO_2 sequestration cannot be done everywhere and projects must be properly managed in order to be safe and effective. For good reason, public acceptance of CCS will happen only if the public is confident that rigorous and credible regulatory oversight is in place. Fortunately, developing sound regulations for geologic sequestration appears to be within our grasp and the country is making excellent progress toward achieving this goal.

The fact that Environmental Defense Fund supports the deployment of CCS does not mean that we are champions of coal. We are pleased that people are increasingly recognizing that energy efficiency and renewables should play a leading role in energy and climate policy. As indicated by McKinsey and Company's U.S. Greenhouse Gas Abatement Mapping Initiative, there are many efficiency and renewable energy strategies that are cost-effective and can be pursued even before CCS is a fully developed, commercial enterprise. CCS is an important part of the solution, but it is only a part.

Although we are not champions of coal at EDF, we are realists. Market forces dictate that coal will continue to be used for electricity production for the foreseeable future regardless of whether its share of the market goes up or down. Therefore the nation and the world need technologies that enable coal to be used in a manner that avoids significant greenhouse gas emissions. According to an IEA study released in 2006, CCS could rank, by 2050, second only to energy efficiency as a greenhouse gas control measure. The Intergovernmental Panel on Climate Change (IPCC) projects that CCS could, by 2100, contribute 15 to 55% of the greenhouse gas reductions needed to avert catastrophic climate change.

I would like to cover several things this morning. My main focus will be to suggest what regulatory elements are needed in order to manage the risks of geologic sequestration, particularly risks that are relevant to the protection of groundwater. I will offer a preliminary assessment of the proposed rules released last week by EPA. I also will comment briefly on progress being made in assessing the nation's geologic capacity for CO_2 sequestration. Finally, I will offer a few observations on liability issues since there is a relationship between an effective regulatory program and the broader legal context in which such regulation takes place.

REGULATORY CONSIDERATIONS - MEASURES NEEDED TO PROTECT UNDERGROUND SOURCES OF DRINKING WATER

Geologic sequestration of carbon dioxide is feasible under the right conditions. It has been successfully demonstrated in a number of field projects, including several large projects. The IPCC Special Report on Carbon Capture and Storage concluded in 2005 that the fraction of CO_2 retained in ″appropriately selected and managed geological reservoirs″ is likely to exceed 99% over 1000 years. The IPCC also concluded that the local health, safety and environmental risks of CCS are comparable to the risk of current activities such as natural gas storage, enhanced oil recovery and deep underground storage of acid gas if there is ″appropriate site selection based on available subsurface information, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO_2 releases if they arise.″

While there is little doubt that geologic sequestration is feasible, and little doubt that successful projects are technically achievable today, knowledge and understanding are expected to increase dramatically as the technology begins to be deployed on a large scale. Current projects are highly customized. Neither government nor industry have yet developed standard protocols for fundamental aspects of the process such as site characterization and monitoring. In fact, due to geologic variability both between and within sites, project design will always need to be site-specific to a significant degree. Still, the IPCC Special Report projects that increasing knowledge and experience will ″reduce uncertainties″ and ″facilitate decision-making.″

In other words, we know enough to get started but we can expect to experience a lot of ″learning by doing.″

What are the implications of this for the regulatory system? We believe at least four recommendations are in order to account for the fact that increasing knowledge and experience will facilitate rational decision-making in different ways over time:

- Lean toward a performance-based system. ″Performance-based″ regulations and ″command-and-control″ regulations do co-exist -- they are two poles on a continuum;
- Be reasonably flexible. Different projects will present different risks and uncertainties, and the uncertainty presented by a single project will tend to decline over time;
- Require projects to employ an iterative process, informed by monitoring results and perhaps even by experience gained from other projects, in order to reduce uncertainty and drive improvements in site characterization, site suitability assessment, models, model inputs, field operations, the monitoring plan itself, and the remediation plan;
- Write ″adaptive″ rules. Look for language that automatically accommodates evolving best practices. Also structure rules to make use of evolving knowledge at each particular site. Be willing to amend rules when needed to protect the environment, giving due regard to the fact that it generally is in the public interest for the regulatory framework to give the regulated community the certainty needed to make investment decisions.

These general recommendations are important, but it is not enough for rules to be flexible, adaptive and performance-based. It is essential that rules be grounded in a thorough, scientific understanding of the risks involved and that rules assure that the risks will be managed properly. In order to accomplish this, some aspects of the rules (e.g. site characterization and site selection requirements) will need to

be more prescriptive than others and the regulatory program must always remain focused on assuring that underground sources of drinking water are not endangered.

How should this focus on protecting underground sources of drinking water be maintained? Regulations governing the geologic sequestration of carbon dioxide must include clear and rigorous standards relating to:

- Site characterization and selection (including modeling, capacity estimates for long-term retention, and risk assessment)
- Operations (including well construction and maintenance, injection practices, purity of the injection stream, monitoring, reservoir pressure management, reporting requirements, and preventive action and/or corrective action as necessary)
- Periodic adjustments over the life of the project regarding any of the above elements if appropriate based on project experience
- Closure procedures
- A post-closure determination that the project does not and will not endanger USDWs

EPA'S PROPOSED RULES FOR GEOLOGIC SEQUESTRATION

How well do the proposed rules that EPA released on July 15 meet these criteria? EDF is still in the preliminary stage of evaluating the proposal, but it is clear that the rules have much to say about each of the regulatory elements just mentioned. The Agency appears to have thoroughly reviewed most of the issues involved and attempted to craft a set of rules that is both protective of the environment and not unduly burdensome for industry. EDF will undoubtedly develop many recommendations for adjustments during the public comment period, including recommendations of fundamental importance, but overall we are pleased at this stage with what we have seen.

Although we are still at an early stage of assessing the proposal, we can offer the Committee some specific comments at this time. For convenience, I will divide our observations into positive comments and not-so-positive comments. First the positive:

1.We believe that the proposal to create a new Class VI category for long-term geologic sequestration of carbon dioxide is a good idea. Creating a separate category is justified by the differences between long-term sequestration and other injection operations - differences that relate to scale, duration, and pressure regimes, and perhaps by other differences as well. Section 146.81(a).

2.Because of the differences just mentioned, we believe that EPA is right to propose to maintain different regulations for Class II wells used for enhanced oil recovery projects. If such wells begin to be used for the purpose of long-term sequestration, Class VI regulations would generally apply at that time. See section 146.81(c).

3.The proposal defines the Area of Review (AOR) to include the entire area that may be impacted by the injection activity, rather than defining the AOR according to a fixed radius around injection wells as is sometimes done in the Underground Injection Control (UIC) program. This is a good and important proposal because of the potentially large areal extent of sequestration projects and the risks that may be present due to elevated pressure. Section 146.81(d).

4.Although some adjustments are probably in order, the scope of information that the proposed rule would require as part of a Class VI permit application appears to be generally reasonable. Section 146.82.

5.Similarly, although some adjustments are probably in order, the proposed minimum criteria for siting appear to be generally reasonable. The criteria have much in common with both established (UIC) principles and with specific recommendations made by stakeholder groups such as the Interstate Oil and Gas Compact Commission and the Ground Water Protection Council. Section 146.83.

6.While once again some adjustments are probably in order, another positive and important provision is the proposal to require a testing and monitoring plan to verify that the sequestration project is operating as permitted and is not endangering USDWs. Section 146.90.

7.The proposed rule properly avoids relying on the simple absence of known problems over a given amount of time following cessation of injection as the basis for determining that USDWs are not being endangered. Section 146.93.

8.The proposed rule includes emergency and remedial response requirements that are clear and rigorous. If an operator obtains evidence that the injected carbon dioxide steam and associated pressure front may endanger a USDW, the operator must immediately cease injection, take all steps reasonably necessary to characterize any release, notify the permitting agency within 24 hours, and follow previously approved plans to address movement of injection or formation fluids. Section 146.94.

We offer the following preliminary comments regarding aspects of the proposed rules that may merit adjustment:

1.Although the proposal defines the Area of Review as the region that may be impacted by the injection activity, the proposed methodology for determining this region may not focus adequately on the potential effects of elevated pressure and displaced brine, as distinct from effects of the carbon dioxide itself. Section 146.81(d).

2.The proposal should take a more sophisticated approach to regulating injection pressure. Injection pressure limitations need to take account of the possibility that under certain conditions faults that would otherwise be nontransmissive can become transmissive even if injection pressures are kept below the level necessary to create new fractures or propagate existing fractures. No single across-the-board pressure limit, including the proposed requirement that injection pressure not exceed 90 percent of fracture pressure, is adequate for this purpose. See section 146.88(a).

3.Although the proposal properly avoids using the simple absence of known problems over a given amount of time as the basis for determining that USDWs are not being endangered following the cessation of injection, the requirement that the carbon dioxide plume and pressure front be ″stabilized″ in order to make this finding is probably not appropriate as a general standard. The World Resources Institute is in the process of completing a set of Guidelines that may prove helpful on this important issue. See section 146.93(b).

Geologic Storage Capacity Assessments

EDF commends the Department of Energy's Regional Sequestration Partnership Program for developing the Carbon Sequestration Atlas of the U.S. and Canada. And we look forward to the more detailed assessments of long-term storage capacity contemplated by the USGS. It is important, however, to understand the purposes for which such studies are and are not useful. Regional assessments can provide general information about where appropriate sequestration sites may be located. They can provide regional capacity estimates that are either more or less accurate depending on the type of analysis that is undertaken. Regional assessments cannot, however, confirm that a particular site is or is not suitable for a sequestration project. Determining the suitability of a site necessarily requires extensive data collection and geologic characterization specific to the location under consideration.

Liability Rules and the Regulation of Geologic Sequestration

A number of people appear to take it as a forgone conclusion that ″liability relief″ is necessary in order for a geologic sequestration industry to develop. Those holding this view are rarely specific about the ″liability relief″ they have in mind. EDF is not convinced that any ″liability relief″ is needed for the carbon dioxide sequestration industry in the long run, although we are open to exploring the possibility of special rules and institutions for early projects (e.g., liability limits for individual companies in carefully defined situations coupled with an industry-funded risk pool to cover damages in excess of such limits).

We would offer the following observations on the subject of ″liability relief″:

- Privatizing benefits while socializing risks is a good way to incentivize inefficient and even dangerous behavior.
- Current liability rules grounded in common law and statutes serve an important purpose - encouraging people to act as their fellow citizens and policymakers expect them to act.
- There is no special ″liability relief″ for the enhanced oil recovery business or the underground injection of hazardous waste business. Natural gas storage is not subject to UIC regulations, but natural gas storage operators are not shielded from liability as a general matter. Yet all three of these businesses inject material into geologic formations and appear to have little trouble attracting investment in the marketplace.
- If liability rules incentivizing good behavior were absent, regulators might perceive a need to adopt rules that were more detailed and prescriptive than would otherwise be the case.
- Those who advocate modification of liability rules for carbon sequestration ought to be clear about what liabilities they would like to see addressed. Do they mean to include liability for contract violations, fraudulent acts, or conversion of other people's property? Do they mean to include liability for intentionally inflicted harms or gross negligence? Do they mean to include all types of damages or just certain types of damages?
- It is one thing to transfer the risk of liability for a well-executed sequestration project, and something else entirely to relieve an operator who has created a project that presents significant risks. In order to distinguish between these situations and

maintain incentives for workmanlike behavior, we believe that the nature and perhaps the existence of any liability modification should depend on whether a project demonstrates following closure that there is a high degree of certainty that USDWs are not and will not be endangered.

- A useful way to think about possible modifications of liability rules applying to geologic sequestration activities would be to ask what novel risks are presented by this activity, the extent to which these risks can be handled in the current marketplace (e.g., insurance, investors shouldering risk in expectation of a higher return), and the extent to which it might be possible and desirable to create new private sector mechanisms (e.g., industry risk pools, new forms of insurance) to address any real problems with capital formation.
- In the event it is found that investment in geologic sequestration is unreasonably hampered by risk management issues, the solution should be tailored to fit the problem and to the extent possible the solution should make use of market mechanisms and risk-sharing within the industry.

CONCLUSION

In a carbon-constrained world where market forces are harnessed to make sure that society's carbon footprint is reduced in an economically rational fashion, Environmental Defense Fund foresees a dramatically increased role for renewable energy and for energy efficiency. At the same time, since any complete transition away from fossil fuels is likely to take a very long time, we foresee a long-term need to deal with CO_2 emissions from coal-based facilities. The sooner we begin to deploy CCS technology on a large scale the better. We applaud you for working on measures to make this a reality.

Mr. GREEN. Thank you. Mr. Yamagata.

STATEMENT OF BEN YAMAGATA, EXECUTIVE DIRECTOR, COAL UTILIZATION RESEARCH COUNCIL

Mr. YAMAGATA. Mr. Chairman, I will—even though I am an attorney. First let me associate myself, point number one, with comments that Congressman Murphy made earlier about the need for coal, the importance of coal, the challenges to coal today, but also the fact that we need coal. To the extent that that is the case and while there are questions about CO_2 which is one of the reasons why we are not building coal plants generally, there is a dash to gas and in that context. FERC has already implied or suggests that we are going to experience rather significant increases in the cost of electricity. That is, sort of a perspective, point number one.

Point number two is that technology is really important to meeting the Nation's climate goals. Let me give you a factoid, if I may. A massive study, just completed by the International Energy Agency identified technologies necessary to meet a global reduction in greenhouse gas emissions of 50 percent below current levels by 2050. CCS, carbon capture and storage, technologies were associated with 20 percent of the total reductions required. The point here is, if CCS cannot be made to work here in the United States and India and in China, it is not coal that will be in jeopardy, it will be the whole issue of trying to meet goals with respect to climate change.

Point number three, CCS should pose no risk to groundwater so long as geologic storage is properly managed. This is the point that other panelists have made this morning. The Intergovernmental Panel on Climate Change concluded that 99 percent of the CO_2 stored in "appropriately selected and managed geological reservoirs" will remain permanently stored in those reservoirs for over a thousand years or more.

Point four, we see four major barriers to the successful deployment of CCS technologies. First, is that all of the pieces needed for capture and storage of CCS are in existence. Most of these pieces have been used in the petrol-chemical industry for years, but we have never assembled these pieces, integrated them together at a commercial scale for use in power generation. So, in point, we have no experience here, not in the United States, not world-wide. All of the pieces need to be put together.

The second barrier is that related to—and the subject of most of the conversation this morning—we have very limited experience with storing large volumes of CO_2. The good news is, it looks like we have, in the North American continent, very huge reservoirs that might be capable of taking the CO_2 that is available or that is emitted today.

The third barrier is cost. For a power production facility, the addition of CCS systems, using currently available technology, could double the cost of electricity when compared to a basic pulverized, coal power plant that could be constructed today without CCS. To address these first three barriers, cost, integration and know-how with respect to storage, CURC has proposed a program that has a cost in excess of $50 billion over an 18 year period to focus our efforts on CCS research development and demonstration, but also, and importantly, to start the process of "putting steel in the ground". So with available technology, things that we know how to do today, we should start capturing and storing CCS and get some of that experience learned by doing.

The fourth barrier, as defined in this whole session today, is the absence of a defined regulatory structure to govern the sequestration of CO_2. The EPA's proposed rule for underground injection control has been that discussion today, and addressing part of the issues with respect to sequestration. This is a proper rule where EPA has aligned itself. That is the limit of their responsibility as provided under the Safe Drinking Water Act, but there are really other regulatory structures that need to be dealt with, some of which have been alluded to today, compression issues, purity of CO_2, the transport of the CO_2, questions about ownership of the pore space, and of course, long-term liability of CO_2 ownership. None of these have been addressed. We call upon the Congress and the Executive branch to address these particular issues, which are very important.

And, finally, let me say that with respect to early adopters, people who are thinking about and willing to take on the projects of CCS today, some clarity needs to be given in the terms of long-term liability. Our proposal is that with respect to a limited number of these projects, Congress or State governments must take on the responsibility of transferring, or taking the transfer, of this long-term liability once the projects have been operated and successfully closed in.

Mr. Chairman, I thank you for the time you have given me and I look forward to your questions.

[The prepared statement of Mr. Yamagata follows:]

Statement of Ben Yamagata

Realizing the Potential of Carbon Capture and Storage Technology

Introduction

The Coal Utilization Research Council (CURC) is an association of coal stakeholders which has the primary purpose of fostering programs of technology research, development, demonstration, and deployment of technologies to enable the continued economic and energy security benefits that derive from coal use, in a manner that is consistent with the nation's environmental policies and goals. CURC members include major U.S. coal companies, coal-using electric utilities, manufacturers of power plants and power plant environmental control systems, major universities with engineering programs related to coal technologies, and major coal-related associations or institutes including the National Mining Association, Edison Electric Institute, the National Rural Electric Cooperative Association, and the Electric Power Research Institute (a list of members is attached). Our major focus is on coal-based power production, because that sector consumes over 90% of U.S. coal production, but our members are also involved in technologies that convert coal to substitute natural gas, chemical feedstocks and liquid transportation fuels. In recent years CURC's highest priority has been the research, development, demonstration and deployment of carbon capture and storage (CCS) technologies.

This written statement focuses upon the need for coal in supplying reliable, low-cost, environmentally acceptable, energy to American consumers and the need to successfully address concerns about global warming impacts associated with the use of coal.

Adequacy and costs of electricity capacity in the U.S.

The U.S. power sector is showing signs of serious stress. In reports issued in May and June of this year, the Federal Energy Regulatory Commission (FERC) pointed to increasing use of relatively costly natural gas and declining electric capacity reserve margins. FERC has predicted 60-120% increases in wholesale electricity prices this summer compared to last summer.[1] These reports followed last winter's report by the North American Electric Reliability Corporation (NERC) that reliability of electricity supply in the U.S. had declined, and would fall below industry standards of acceptable reserves on both U.S. coasts by 2009.[2]

Attempts to construct coal-fueled power generation have been met, in many instances, with opposition by non-governmental entities and deepening concerns over costs and CO_2 impacts by government entities. During 2007, over 30 proposed coal-based power plants were postponed or cancelled. Proposed plants were stopped by Public Utility Commission objections to escalating costs (or potential future costs related to CO_2 emissions), or by environmental permitting agency objections to CO_2 emissions, even in the absence of CO_2 regulatory requirements. The general response has been to propose the construction of natural gas-based power plants that are less costly to construct, easier and quicker to obtain necessary government permits, and emit about one-half the CO_2 of a coal-based power plant. But these generating plants will use a fuel that currently costs more than five times as much as coal. The DOE/Energy Information Administration predicts electricity price increases of 15% by the end of 2009, but utilities in a number of states have already registered rate increase requests of 20-30%, and most of these have cited escalating fuel prices.[3]

The economic challenge of climate change mitigation must somehow be accommodated in this already highly volatile marketplace.

CCS technology is critical to meeting the nation's climate goals

The CO_2 emissions from coal (about 33% of U.S. manmade CO_2 emissions) and natural gas-based power (natural gas-based electricity also contributes to the U.S. total CO_2 emissions - about 6% of the total) constitute a large percentage of overall CO_2 emissions even while these fossil fuels contribute, by far, the largest percentage of available electric capacity to the Nation's power grid. Those CO_2 emissions can be reduced by improving generation efficiency, or by improving end-use efficiency, but a major reduction will require the widespread adoption of carbon capture and storage (CCS) technology. CCS technology involves two steps: separation and compression of CO_2 at the power plant, and transport and storage of CO_2.[4]

The significance of CCS technology to achieving climate goals was demonstrated in a massive study published this year by the International Energy Agency (IEA), an arm of the (spell out acronym)OECD. The study, Energy Technology Perspec-

tives: 2008, identified technologies necessary to meet a global reduction in greenhouse gas emissions of 50% below current levels by 2050. CCS technologies were associated with 20% of the total reduction required, and the IEA stated that, ″There is an urgent need for the full-scale demonstration of coal plants with CCS.″ In EPA's analysis of S.2191, the Lieberman-Warner climate bill (as initially introduced), that Agency determined that CCS was critical to controlling overall compliance costs. More recently, Senator Bingaman emphasized the need to pursue CCS technology and stated, ″We need to invest in this technology agenda immediately, even before the implementation of a cap-and-trade system, so we can figure out right away if our caps are based on technically viable options ..″

In other words, if CCS cannot be made to work, it is not coal use that is in jeopardy, it is the climate goals that many (including many in Congress) are seeking to achieve.

CCS RISKS TO GROUNDWATER

On July 15, EPA proposed rules to regulate CO_2 storage through the Underground Injection Control (UIC) program. The major potential impacts of CCS on underground sources of drinking water (USDW) were identified as: leaching of metals and mobilization of other contaminants by CO_2 or dilute carbonic acid formed from CO_2, and contamination of drinking water by pollutants in the CO_2 injectant stream (the CO_2 itself is not a problem). In other words, if these impacts were to occur they would most likely be the result of an improperly managed geologic storage facility in which CO_2 leaked from its designed containment area and reached an USDW. Both the rules recently proposed by the US EPA and model State regulations developed by the Interstate Oil and Gas Compact Commission (IOGCC) include provisions for selecting storage sites which have a high probability of retaining injected CO_2. These proposed programs also include requirements for periodic or continuous monitoring of conditions underground to detect and mitigate unexpected leaks before the CO_2 would ever reach valued USDW resources.

It should be noted that the Intergovernmental Panel on Climate Change (IPCC) has concluded that, ″Observations from engineered and natural analogues as well as models suggest that the fraction [of stored CO_2] retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years.″ Experts from around the globe agree that once properly stored, the likelihood of any significant leakage of CO_2 is miniscule.

MAJOR BARRIERS TO CCS DEPLOYMENT

CURC believes that there are four major barriers to deployment of CCS technologies.

- The first is that the needed capture technology, which exists and has been used in the petrochemical industry, has never been deployed on a commercial scale with power generation. Integrating these CCS systems, which can consume 15-30% of the energy used at a power plant, with the basic power plant system is challenging.
- The second barrier is that we have very limited experience with storing large volumes of CO_2. The four largest commercial scale projects in the world, taken together, are approximately the storage rate required for 85% capture on one large coal-fired power plant. EPA confirms what the Department of Energy and others have reported, that there are vast potential resources within the North American continent to store as much as 3,900 billion tons of CO_2; current annual CO_2 emissions for all U.S. sources are approximately 6 billion tons so there is potentially hundreds of years of storage capacity available.
- The third barrier is high cost. The four CO_2 storage projects cited above are all non-power applications in which the separation of CO_2 from other gases is part of the basic process of energy production or conversion, and creates very little additional cost. For power production, the addition of a CCS system, using currently available technology, can double the cost of electricity generation, compared to a basic pulverized coal power plant that could be constructed today without CCS.
- The fourth barrier is the absence of a regulatory framework governing storage of CO_2.

Regarding this last barrier, two potential regulatory frameworks have received attention. The first is the aforementioned EPA proposed rule on UIC. That rule is focused almost entirely on potential impacts on USDW, as it must be since it draws its authority from the Safe Drinking Water Act. The second is a set of model legislation and model implementing regulations developed by the Interstate Oil and Gas Compact Commission (IOGCC). The IOGCC package is much broader in scope than the EPA proposed rules because it includes its own enabling legislation specifically

tailored for CO_2 storage systems. The IOGCC proposed rules draw from two decades of state regulatory and industry experience with compression, transport, and injection of (primarily natural) CO_2 for enhanced oil recovery.

RECOMMENDATIONS TO OVERCOME BARRIERS TO CCS DEPLOYMENT

CURC believes that two actions are needed over the next couple of decades to overcome the four principal barriers to CCS deployment that are identified above. The first action is that we must act now to provide financial incentives that result in immediate deployment of a limited number of CCS-equipped power plants or synfuel facilities equipped with currently available CCS. Without hands-on experience integrating CCS technology with power plant technology, and the associated experience with large-scale CO_2 storage systems in multiple geological formations, technology will not reach a full-deployment capability. Industry, regulators and the public need this early experience to validate our ability to address CO_2. In addition, early CCS projects - undertaken now - will assist in realizing cost reductions via this ″learn by doing″ effort.

We need to recognize that CCS deployment will be a ″crawl, walk, run″ process, rather than one in which we begin by ″running.″ This technology maturation process - first crawl, then walk, and finally, run -- has several important implications for policy makers. One immediate policy implication is that government financial incentives should not be predicated or conditioned on achieving high fractions of CO_2 capture, like 85% or 90% capture. Such a significant percentage requirement is tantamount to running when we do not yet know how to crawl. It is true that we need experience with large-scale storage, but that can be better accomplished with a requirement for a significant annual storage tonnage, such as one million tons per year of CO_2 storage.

Another policy implication is that we need a flexible interim set of rules for CO_2 storage for those willing to be the ″first adopters″ of CCS projects. It needs to be emphasized that the proposed EPA rules only cover one aspect of the needed legal framework, that is, the injection of CO_2 into underground storage reservoirs. In addition, these rules will apply well into the future and for vast tonnages of stored CO_2 and given this importance and longevity the actual adoption of these rules may be years away. For those early adopters of CCS projects that are coupled to coal-based energy conversion projects wishing to go forward now, we need an interim approach that addresses both EPA's concerns as well as broader legal and regulatory uncertainties that are outside EPA's legislative authority. CURC is very mindful of the absolute need to protect the public and USDW, that will be achieved presumably through the adoption of some form of the proposed EPA regulations for CO_2 injection as well as state or federal adoption of ″how to″ procedures as reflected, in part, by such model legislation and regulations as developed by the IOGCC. Again this process to be accomplished correctly may require years to complete. And, it should be emphasized that it is far preferable ″to get it done right than to get it done quick.″

The CURC proposes an interim program that is predicated upon an assurance to ″first adopters″ that the long-term liability of stored CO_2 would be transferred to and accepted by government. Initially, a CCS project would be responsible for the storage of CO_2 during operation of the project and for a period of time (e.g. ten years) after cessation of project activities during which the owner or operator would remain responsible for monitoring and verification post-storage shutdown. Without such assurances through some form of interim program, it is difficult to foresee how any initial CCS project, not knowing the ″rules of the road″ can proceed.

This Committee is urged to become actively involved in the consideration of such an interim program as a necessary step to avoid the delays that will confront the early demonstration and deployment of commercial-scale CCS projects that will otherwise await the installation of a regulatory and liability structure.

A final policy implication is that these pioneering CCS projects will not finish the job. These near-term activities have the potential to greatly accelerate full deployment of CCS technology. However, in order for this technology to be affordable, both in the U.S. and for the high growth coal nations of China and India, we must redouble our commitment to RD&D. This includes research on more efficient coal-based power systems (which emit less CO_2 even without CCS systems), as well as research on lower cost power systems equipped with CCS. Little progress will be registered in mitigation of CO_2 emissions from coal if we fail to develop CCS technologies that are affordable for all major coal using nations. But the larger message here is that it will take time to complete this needed RD&D. If we press for immediate emission reductions from the power sector, we are likely to see utilities abandon coal for natural gas, an action which will meet their early emission compliance needs. However,

the reliable and affordable CCS technology which is ultimately needed for both coal and gas will not receive priority attention under this scenario, and will therefore not be available when it is needed. For more information on this longer term RD&D effort I would refer readers to the CURC-EPRI Roadmap.

All told, CURC estimates that the two technology development programs presented here, the immediate deployment program and the longer term RD&D effort, will cost well over $50 billion, spread over two decades. If we are to be successful Congress must join with industry to jointly provide sufficient time, focus and money to develop and apply those technologies that will allow us to be successful. A sustained partnership of great magnitude will be required.

Conclusions

The following general conclusions can be drawn from the above discussion:

- The U.S. power sector, beginning now, will exhibit sharp increases in prices, compared to previous years. Electricity reliability will deteriorate over the next few years, with a higher probability for blackouts during peak demand periods, beginning in some regions in 2009.
- Coal provides one-half the electric power generated in the U.S. and one-third of the nation's CO_2 emissions. Coal is essential for meeting U.S. power demand, and CCS technology is essential for coal to meet its environmental responsibilities. CCS is also needed for natural gas generating technologies, which contribute a significant portion of U.S. power generation.
- Storage of CO_2 presents two types of risk to underground supplies of ground water: potential contamination by metals and other compounds already in the ground, but mobilized by CO_2 injection or weak acids created by CO_2 injection and migrating to the USDW reservoir; and contamination by trace materials injected along with the CO_2. Both of these risks would only manifest if the CO_2 storage structure were improperly chosen or maintained. Both EPA and the IOGCC have formulated regulations that, if adopted and implemented, would negate that eventuality. The IPCC has concluded that a properly sited CO_2 storage project will have an extremely low probability of releasing CO_2 into rock strata where contamination of ground water could occur.
- CCS is an emerging technology that must overcome significant barriers before it will be available for broad deployment to mitigate CO_2 emissions from the power sector. However, CURC and others have identified those barriers and CURC has proposed a reasoned plan to overcome them. The plan includes immediate deployment of a small number of power plants with existing CCS technology now, and a longer term RD&D effort to produce a sharp reduction in the cost of CCS. CURC believes that a nurturing regulatory environment and financial assistance will be needed to ready CCS technology for broad commercial deployment.

[1] 2008 Summer Market and Reliability Assessment, Item No.: A-3, Federal Energy Regulatory Commission, May 15, 2008; and Increasing Costs in Electric Markets, Item No.: A-3, FERC, June 19, 2008.

[2] 2007 Long-Term Reliability Assessment: 2007-2016, North American Electric Reliability Corporation, October 2007.

[3] Short Term Energy Outlook, July 2008, USDOE Energy Information Administration. Price Jolt: Electricity bills going up, up, up, USA Today, June 20, 2008.

[4] CCS, in this statement, can refer to both the storage of CO_2 into deep geologic formations as well as the use of CO_2 in the recovery of crude oil referred to as enhanced oil recovery (EOR). Also references to CCS, in the context of possible government incentives, can also include CO_2 captured from coal to liquid fuels, chemicals, industrial feedstocks or substitute natural gas.

[5] Finding the Path Forward on Climate Legislation, speech to NDN, Sen. Jeff Bingaman, July 9, 2008.

[6] EPA press release and Notice of Proposed Rulemaking are available at: *http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/d35b72dfe481043b85257487005e47cd!OpenDocument*.

[7] Carbon Dioxide Capture and Storage, IPCC, 2005.

[8] Moreover, for over 15 years, acid gases (including CO_2 and much more hazardous hydrogen sulfide) have been injected into saline geologic formations in western Canada. The Alberta Research Council and Energy & Utilities Board report that, "By the end of 2003, approximately 2.5 Mt CO_2 and 2.0 Mt H2S have been successfully injected into deep hydrocarbon reservoirs and saline aquifers in western Canada. . No safety incidents have been reported in the 15 years since the first operation .." These injection and storage operations are smaller than those needed for electric power plants and the Canadian report cited the need for assessing long-term containment and large-scale operations. From: Overview of Acid-Gas Injection Oper-

ations in Western Canada, Bachu (Alberta Energy and Utilities Board) and Gunter (Alberta Research Council), Proceedings of the 7th International Conference on GHG Control Technologies, IEA GHG Programme, 2005.

[9]These projects include: Sleipner, which captures 1 million tonnes per year of CO_2 from natural gas production in the North Sea; Weyburn, which captures 1.7 million tonnes per year from substitute natural gas production from coal in North Dakota; In Salah, which captures 1 million tonnes per year from natural gas production in Algeria; and Snohvit, which captures 0.7 million tonnes per year from natural gas production in the Barents Sea.

[10]Storage of Carbon Dioxide in Geologic Structures - A Legal and Regulatory Guide for States and Provinces, IOGCC, September 25, 2007.

[11]It is not intended to assert that the adoption and successful pursuit of these two programs will thereby be sufficient to insure the continued long-term use of our Nation's coal resources nor the widespread commercial use of these technologies. Adoption of these programs will best insure that CCS technologies will have been developed and initially deployed, widespread commercial use may require additional programs or assistance.

[12]CURC - EPRI Roadmap for Advanced Coal Technologies, *www.coal.org*.

Mr. GREEN. Thank you. I think I will try and get my questions out of the way and as soon as I finish mine we have a—just heard the 10 minute bell and if members want to go to—and we will reconvene as soon as the votes are finished.

Mr. Duncan, again, welcome to Washington. Your testimony cited that 80 percent of the world's underground injection of CO_2 occurs in the Permian Basin in west Texas to enhance domestic oil production. In what way is our experience with enhanced oil production, or EOR benefit sequestration efforts to reduce greenhouse gasses—emissions? And I know you said in your testimony that there is no monitoring now, if there are releases from that, but we have a lot—

Mr. DUNCAN. Let me correct that. There is monitoring for safety purposes, but not in terms of broad field leakage. So we monitor around the wells. We monitor the pipelines and so on. I think the first basic experience is handling CO_2, transporting CO_2, pipelining CO_2 and the CO_2 pipeline industry has the best safety record of any pipeline in the Country. Their safety record is better than natural gas, so we have been able to demonstrate that you can produce CO_2 and pipeline it over large distances safely and effectively.

Mr. GREEN. We do have some CO_2 pipelines that are in functioning now.

Mr. DUNCAN. Yes. There is a large network of CO_2 pipelines that bring natural CO_2, largely from Colorado, down into west Texas. They also separate CO_2 in Texas from natural gas production and pipeline that out to the oil fields.

Mr. GREEN. Okay.

Mr. DUNCAN. So I think in terms of the technology for injecting CO_2, monitoring CO_2 in the subsurface, this is all being developed by the oil industry, in relationship to CO_2 enhanced oil recovery.

Mr. GREEN. EPA estimates that domestic oil recovery equals only about four percent of the total domestic capacity for sequestration, which sounds small, but that seems— that is still 90 gigatons of CO_2. Can you give us a ballpark estimate on how long it would take us to fill up the bulk of that capacity under an aggressive and a conservative outlook for CCS?

Mr. DUNCAN. I can give you some numbers for Texas. The Bureau of Economic Geology has estimated, fairly conservatively I think, that there is 3.8 billion barrels of oil could be recovered in Texas, outside of the Permian Basin. That is in the Gulf Coast and east Texas, through use of CO_2. We have also estimated that somewhere between five and six billion tons of CO_2 could be sequestered as part of this EOR. To give you some idea of the magnitude of that, station resources in the Gulf Coast will produce, over the next 50 years, probably about 60 billion tons. So it is not going to take care of all the CO_2, but it will help us develop a pipeline infrastructure compression that can be later used for injecting into brines. We have also estimated there is over 200 billion tons of capacity in the Deep Brine's along the Gulf Coast and in east Texas.

Mr. GREEN. Okay. I appreciate your testimony. It is helpful. One of the questions that came from some of the committee members at the first panel and I guess for this panel is, in the ground now, the experience in west Texas particularly, CO_2—and if often times after a decade or two, it merges with whatever rock formations is there, particularly if there is a coal seam, and very deep. Is that generally what you understand, or with your experience?

Mr. DUNCAN. I think we are just starting to develop an understanding of what is happening with CO_2 and enhanced oil recovery. There hasn't been a lot of interest in the past. As long as the oil flowed, people didn't worry, about what was going on. We believe that, probably, most of the oil, at least I believe, that most of the CO_2 that doesn't come out is actually dissolved in oil that is just still trapped down there, and the rest of it is either dissolved in brine that is in association with the oil or trapped in pore spaces within the brine.

Mr. GREEN. Okay. Thank you. Mr. Yamagata, is it possible to rank the major carbon capture methods, in terms of the levels of contamination, or do they perform all about the same and what contaminates are present in what contamination. I know sulfur, and maybe other things.

Mr. YAMAGATA. Well, the importance of technology development, Mr. Chairman, is that we are going to get the emission levels of criteria pollutants, as well as CO_2, down to miniscule levels, in some cases, almost non-detectable. In the context of your first part of your question, however, and that is the type of platforms that we are trying to develop or that are already developed for the capture of CO_2 and that is in the context of really thinking about combustion based systems that produce Bauer—or, as you have heard before, gasification based systems that also produce electric power and other things as well.

In those two instances, the goal here is to capture at least 90 percent of the CO_2, at a cost that is no greater than, say, 20 percent of what the costs are today without CO_2 capture. Those are goals, of course. Technology development will flow out of whether or not we are successful there. The other important point here, however, is that we need to start doing things now. If we can't do 90 percent now, economically, let us start doing something, just learning by doing and letting that, in itself, bring down costs and give us a better understanding of what we need to do next.

Mr. GREEN. Thank you, and my time is expired. And, again, the committee will stand in recess until the finishing of the final vote and it will be our ranking member's turn.

[Recess.]

Mr. DUNCAN. There are some studies going on, but I don't think we are getting the kind of information that we could get out of that and some of the other projects—long-term sequestration projects in the Permian Basin.

Mr. SHADEGG. I am curious, the carbon dioxide that was used there, and is currently sequestered, came from where? Was it taken from the earth and other locations and brought?

Mr. DUNCAN. The CO_2, in general, from the Permian Basin, 90 percent of it comes from natural sources of CO_2, mostly up in Colorado. And about 10 percent, at the moment comes from gas separation plants. That is where we are producing natural gas that it has too much CO_2 in it so they separate it out using that, and that gets counted as anthropogenic or man-made CO_2 because it is man's activity that is producing it. The Sacroc Project, historically, began with 100 percent of that CO_2 from the gas separation plant and I think, at the moment, about 20 percent of it is coming from that source.

Mr. SHADEGG. If the CO_2 is taken from the gas separation process, had that CO_2 not been used for enhanced oil recovery, would it have just gone into the environment?

Mr. DUNCAN. That is correct.

Mr. SHADEGG. I find some irony that my friends that were deeply worried about the impact of CO_2 on the environment, who don't really like oil, have been benefiting by the fact that the oil industry has been sequestering a whole lot of CO_2, apparently for the last 35 years, and apparently benefiting—if in fact, carbon dioxide is damaging the environment and causing enhanced global warming, we have been fighting it for 35 years without knowing it.

Mr. DUNCAN. Correct.

Mr. SHADEGG. You mentioned that Congress had cut funds for the study of enhanced oil recovery and, therefore, cut funds, kind of I would suggest perhaps, unwittingly for the study of carbon dioxide sequestration. Is that correct?

Mr. DUNCAN. Yes, I think that is correct. The oil and gas part of the Department of Energy was cut and much of that money went to fund graduate student research, faculty research. In other words, it was training the next generation of petroleum engineers with expertise in CO_2. And a considerable proportion of that was actually related to CO_2 enhanced oil recovery.

Mr. SHADEGG. How much of the CO_2 that is put back in, in the EOR process, is sequestered?

Mr. DUNCAN. Ultimately, all of it is. In other words, it is a recycling process, so it cycles through and every time you cycle through it, more of it gets trapped. And how much gets trapped per cycle depends on the actual geology of the individual field and the way they are doing the injection, but ultimately it will all be—

Mr. SHADEGG. My next question is for Mr. Broussard, and it goes to the issue of water quality. Do any of you—but before I go there, do any of you want to comment on the series of questions we just had. Sometimes I see people fidget and know they have a gem of

knowledge they want to put across and I am anxious to hear it because you are teaching me a lot and I appreciate it. Mr. Anderson.

Mr. ANDERSON. Two comments, first, Environmental Defense Fund agrees that there is a happy win-win situation between CO_2 sequestration and enhanced oil recovery. The second comment, although I am really reluctant to disagree on technical matters with Ian Duncan, I think it is important to say that business as usual EOR, even if, in fact, it has sequestered 99 or 100 percent of the CO_2, we don't know that for a fact.

Mr. SHADEGG. Well that was his whole point about, we aren't studying this. I mean, it could be leaking out somewhere else. It could be doing other things.

Mr. ANDERSON. It is also important to do some additional geologic characterization between the time you do the EOR project and the time you do sequestration because the EOR operations could have damaged the reservoir. You need to make sure that didn't happen.

Mr. SHADEGG. Mr. Yamagata.

Mr. YAMAGATA. Mr. Shadegg, just another point here. I made reference, in my comments, to the need to do integration between power generation and capture. And one way to speed that process along, to address the greenhouse gas issues, is to do the power generation with the capture, with the EOR application versus trying to put CO_2 into deep saline formations, and you could just move that thing along quicker.

Mr. SHADEGG. If I understand what you are saying, right now we don't have a place where we can, even experimentally, sequester substantial quantities of CO_2, but we could be capturing CO_2 in the industrial process and using it in EOR processes, creating the demand and creating the entire cycle and study how it works.

Mr. YAMAGATA. We do have places, but part of the difficulty here is just the risk, and lack of understanding, at this point, of putting large quantities of CO_2 into these deep saline formations. So if we want to move the process along, capturing the CO_2 from power generation or from using coal for liquids or subsic gas or anything like that, you capture that CO_2 and use it for EOR purposes. We are still doing half of the equation here and getting more experience as a result of that.

Mr. SHADEGG. Learning from the process?

Mr. YAMAGATA. Right.

Mr. SHADEGG. Mr. Broussard, mine is kind of a comment, but I would be happy to have you respond to it. And that is, in your testimony you stressed the importance of studying the impact of carbon sequestration on water supplies because that is what you guys are about, and you noted that some of that is being done or proposed to be done by EPA. Several of the witnesses, today, have made it very clear that they have a very strong scientific belief that this can be done without damage to the environment and without damage to water supplies. If I have a question, it is, is AWWA doing its own independent studies of that issue? Or, alternatively, would you consider it, because I am a little—I would feel more comfortable if somebody other than EPA were, kind of, checking EPA's work, so that EPA wasn't the only source of telling us, "yes, this is safe." And maybe that involves AWWA getting a grant from

the government so that, you know, we have two people looking at it, not necessarily from the same perspective, one of whose primary interest is ensuring safe drinking water.

Mr. BROUSSARD. Appreciate the question. There is some independent research going on, outside of the work that the EPA is doing and is proposing to do and while I don't have a comprehensive list today, I would be glad to provide some resources to indicate what research is already being done.

One of the main concerns that we have—and I just wanted to express it, I didn't really say it, this out rightly, in the testimony, but the main concern is that the injection site will go through the underground source of drinking water, if one of those sites is selected because of the geology and other consideration. And the fact it penetrates is an area where there could be some contamination or water quality issues.

Mr. SHADEGG. Yeah, I have seen them. There is a graph we have that shows how it happens and it goes through the recovery of the drinking water. The Chairman has indulged me. I am way over my time. I want to thank all of the witnesses on this panel and on the previous one. It has been a tremendous education for me.

Mr. GREEN. Well, one, I—the questions you ask and the responses because we are all learning and, you know, our committee is responsible for the Safe Drinking Water Act and that is our concern and I just want to follow up. When they go through—because there are parts of my area, in the Gulf Coast, that we are always going to have—you are going to go through water. You are going to go through our water table. Is there a way you can do it and still get to those salt domes that we have all along the Gulf Coast?

Mr. BROUSSARD. I guess, if I had my preference, I would just ask that there would be strong considerations made to not permit a Class VI well in an underground source, especially if there is a sole-source designation. That is the main concern that I would have. As far as your question, I don't know if there is another way around it, other than avoiding the source of drinking water.

Mr. GREEN. And I agree with the sole-source and I appreciate your testimony on that because we don't want to contaminate that, but we do have—and, you know forgive me, I was a lawyer in my earlier life like Mr. Yamagata and was a business major and ran a business, but the way I understand what we do now with energy is that they, typically, if there is a resource there, whether it is oil or natural gas, they pretty well know, generally, the pool and where it is at, and are we using that information now to be able to put—I mean, maybe we didn't care about what happened to the carbon once it went in and, you know, pushed out the oil or gas, but because we may want to use it for sequestration and we could use some of the same studies that maybe that they are doing to get that resource out to also make sure that one is not contaminating any ground water, which we also have the concern with the production of oil and natural gas too. We don't want to have that, so Dr. Duncan is that something that we could expand on that—and, also, I know that our regulatory agency from Arkansas, because in Texas we have our Railroad Commission that does, mostly, our oil and gas work. Don't ask me why it is Railroad Commission, but in 1877 we kept that. But is that something that the regulator for the

State in permitting could also take advantage of the information that is provided to you, as a regulator of your natural gas wells, particularly, in Arkansas?

Mr. BENGAL. Yes, it was the Railroad Commission in Arkansas at one time, too, but we changed——

Mr. GREEN. We haven't gotten around to changing.

Mr. BENGAL [continuing]. Our name. I know you tried, but to answer your question yes, that is taken into account. I might add two things. One, under the U.S. EPA UIC program, States that have primacy basically implement the UIC requirements for the EPA in that State. A State is perfectly able under that primacy agreement with the U.S. EPA, to enact more stringent regulations in that particular State if it desires to do so. It is not limited to just what the EPA says, so that if a State has a concern about a particular area of faulting or seismic activity or there is any other issue of concern to the State, it can actually enact more stringent regulations than the EPA regulations. And with respect to another question earlier concerning business models, there are companies right now who are, basically, scouring the countryside, rounding up sources of CO_2 for Enhanced Oil Recovery (EOR) use. There is a real shortage of CO_2 for EOR use.

Mr. GREEN. Well, if you would listen to most of us, you would say we have no shortage of——

Mr. BENGAL. That is carbon.

Mr. GREEN. Or CO_2. Let me follow up, Mr. Bengal, with the EPA proposed rule which set a minimum standard for State carbon sequestration permits. And it is my understanding the EPA has contacted States to hold off on issuing your own rules until the EPA is finished. Do you believe that State regulators could implement both, like you said the UIC, but also add additional requirements onto it? Is that part of what the EPA is allowing, to carry that tradition forward on this?

Mr. BENGAL. Yes, that is part of the current UIC program, and when a State would apply for primacy under the new Class VI program, I assume that the same thing would apply in that a State could actually make those requirements more stringent. The parts of the EPA rule that don't cover initial siting, like ownership issues and long-term liability, could actually be handled under State authorities that exist now.

Mr. GREEN. Okay. Are you aware of any private property lawsuits in States that are involving sequestration?

Mr. BENGAL. There are none that I am aware of. Now there have been several issues dealing with subsurface trespass relative to EOR, but since sequestration is not actively taking place, there has not been an issue with regard to that. The IOGCC did a legal analysis of the ownership of pore space as part of our report. I would just add, too, that even though you see the map of many large areas where sequestration could occur, there is an ownership component that will have to come into play. Not every location where you could theoretically do sequestration, will you actually be able to do it by the time you take into account cities, towns, Federal lands, things like that. And when you get down to having to own the exact place where you will store, there will be a real competition for the good sites within States. And this is where State au-

thorities will have to come in to resolve those conflicts such as when a site is being leased by two companies, which company gets to operate that site? It is up to the States to maximize the storage space use, or you could end up wasting that storage space and not being able to store as much CO_2 as you could if you took care of it properly.

Mr. GREEN. Mr. Anderson, let me ask one last question, and I know before your current position at Environmental Defense Fund you represented independent oil and gas producers, is action to address climate change compatible with leveraging the market economies of the enhanced oil recovery to drive the innovation in sequestration that would broaden to sequestration and deep saline aquifers? Do we have enough of that—is there enough push on the climate change to be able to drive the technology and have that twofer, that win-win?

Mr. ANDERSON. I think you are asking if we need complementary measures to accelerate the technology, in addition to a policy of, say cap and trade. Is that—

Mr. GREEN. Sure.

Mr. ANDERSON. Is that the question?

Mr. GREEN. Yeah.

Mr. ANDERSON. Yes. I think—well it depends on when you think that CCS needs to begin playing a major role as opposed to a transitional role. There are a lot of things that are less expensive than CCS that we can do to help mitigate climate change. And, therefore, those are more likely to be the things that are adopted on a large scale early on. On the other hand, as Ben would be quick to say, we know we are going to need CCS as soon as possible, and therefore there is probably very good reason to have complementary policies to help incentivize the technology and accelerate its development. As far as the degree to which our knowledge in EOR can be translated to saline aquifers I think to a very great degree, it can. The big uncertainty is for the brine formations, which I think are more case specific than generally understood. The basic big question mark for whether you can do sequestration in a brine formation is—really has to do with the question of whether you know enough in advance about the seal quality and the lateral extensiveness of the seal. And since you don't have a lot of development that has already taken place, like you do in an oil reservoir, that is a really big question and the only way to answer that question is to either do tests or to just start your project and see how it goes.

Mr. GREEN. Well, and I know we have tests from the first panel's testimony. Any other comments?

Mr. BROUSSARD. If I may, Mr. Chairman, one of the issues that was brought up earlier by Mr. Bengal was—and I think maybe you brought it up earlier, was about the boundary issue between a State—the Chicot Aquifer is my sole-source aquifer and it does exist, partly, in Texas and mostly in Louisiana, so if you have a State primacy agency in Texas that rules on a Class VI well and it affects something of Louisiana, you have an interstate commerce or some other complicating issues. I just wanted to bring that up.

Mr. GREEN. Yeah, that is a concern I have with, you know—because traditionally, if the States do have some regular authority working with EPA on the others.

Mr. BENGAL. That is pretty much handled in oil and gas. There are oil fields, now, that cross State boundaries, waterfloods across State boundaries and the States handle that. What we do with Louisiana now is to handle it with MOUs between the States, interstate agreements that allow regulation on both sides of the border. So, that exists in the oil and gas industry now.

Mr. GREEN. And, again, from your testimony, EPA is going to continue that relationship that they have with the States being able to have some authority in there.

Mr. BENGAL. There would be nothing in the rules that would preclude a State from entering into arrangements with adjoining States to address cross-State boundary issues.

Mr. GREEN. Mr. Shadegg, I actually had two rounds so.

Mr. SHADEGG. Be my guest, I am fine.

Mr. GREEN. Being no other questions, one thank you for your time this morning and appreciate it. That concludes the statements of the second panel, and I want to remind members you may submit additional questions for the record to be answered by relevant witnesses. The questions should be submitted to committee clerk in electronic form within 10 days and the clerk will notify your offices of procedure. Without objection this committee is adjourned. And again thank you for being here.

[Whereupon, at 2:00 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

Storage of Carbon Dioxide in Geologic Structures

A Legal and Regulatory Guide for States and Provinces

The Interstate Oil and Gas Compact Commission

Task Force on Carbon Capture and Geologic Storage

September 25, 2007

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Storage of Carbon Dioxide in Geologic Structures

A Legal and Regulatory Guide for States and Provinces

In July of 2002, the Interstate Oil and Gas Compact Commission (IOGCC), with sponsorship from the U.S. Department of Energy (DOE), convened a meeting of state regulators and state geologists in Alta, Utah. The purpose of the meeting was to decide whether or not oil and natural gas producing states, and in particular the oil and natural gas regulatory agencies in these states, might be able to play a meaningful role in the sequestration (otherwise known as "storage") of carbon dioxide (CO_2). The meeting concluded that states were indeed interested in examining the issue further.

In response to that meeting, the IOGCC in December 2002 passed Resolution 02.124 calling for the establishment of a "Geological CO_2 Sequestration Task Force". (Subsequent IOGCC resolutions in 2004 {04.102} and 2006 {06.102} have extended the work of the Task Force.) On July 14, 2003, I appointed Lawrence Bengal Chairman of the Task Force. Its membership included representatives from IOGCC member states and international affiliate provinces, state and provincial oil and gas agencies, DOE, DOE-sponsored Regional Carbon Sequestration Partnerships, the Association of American State Geologists (AASG), and the oil and natural gas industry.

Funded by DOE and its National Energy Technology Laboratory (NETL) through a cooperative agreement with the University of Illinois, the Task Force began an examination of the technical, policy, and regulatory issues related to the safe and effective storage of CO_2 in subsurface geological media (oil and natural gas fields, coal seams, and deep saline formations) for both enhanced hydrocarbon recovery and long-term CO_2 storage. The culmination of this effort was the Final Report that was publicly released in early 2005 (This phase of the Task Force is henceforth referred to as Phase I).

A key conclusion of that report was that given the jurisdiction, experience, and expertise of states and provinces in the regulation of oil and natural gas production and natural gas storage in the United States and Canada, the states and provinces would be the most logical and experienced regulators of the geologic storage of carbon dioxide.

Although the Task Force recognized in Phase I that states and provinces with Oil and Natural Gas Conservation Acts and states and provinces with natural gas storage statutes might be able to utilize those statutory and regulatory frameworks for CO_2 injection and storage, it also concluded that some modification of those frameworks might be advisable or necessary, particularly for the post-operational phase for which no regulations exist. The Task Force also recognized that further research into the ownership of subsurface storage rights with respect to CO_2 storage, as well as an analysis of the regulatory relevance of the Underground Injection Control Program (UIC) of the Safe Drinking Water Act and its applicability to CO_2 storage, would be useful to the states.

To this end, the Task Force, under the sponsorship of DOE/NETL, began work on a second project in 2006 (Phase II) to start development of this detailed Guidance Document. Composition of the Task Force was much the same as in Phase I, with the addition of

representatives from the U.S. Environmental Protection Agency (EPA) and the U.S. Bureau of Land Management (BLM) who attended as observers.

The most critical component of this document is a Model CO_2 Storage Statute and Model Rules and Regulations governing the storage of CO_2 in geologic media and an explanation of those regulatory components. Also included herein is a report addressing the ownership and right of injection of CO_2 into the subsurface.

Given the breadth and complexity of the regulatory issues addressed in this report, the Task Force relied on several guiding principles in its drafting efforts. These principles enabled the Task Force to effectively direct its efforts in addressing this complex issue:

SEAMLESS - The statutory and regulatory framework developed needed to be seamless to maximize economic and environmental benefits while providing a "cradle to grave" framework with fully integrated regulatory oversight and clearly identified risk parameters for industry.

SIMPLE - The temptation to over-regulate for the exotic needed to be avoided by developing a simple framework that initially addressed only those scenarios most likely to occur. It was recognized that, as necessary, regulations would be amended in the future based on the experience gained in the initial projects.

FLEXIBLE and RESPONSIVE - "One size will not fit all". Proposed projects will have many site-specific variations throughout the states and provinces and therefore it was recognized that any regulatory framework needed to flexible and responsive to the site variations and developing technologies. Regulatory experience and technology developments are certain to change over time, and each project will only improve the regulatory and technical knowledge base.

DOABLE - Given the speed at which this issue is progressing, a regulatory framework that can be rapidly implemented and fielded was necessary. The Task Force recognized that problems will occur; however, it also recognized that most of those problems are issues with which the states/provinces and oil and gas industry have already dealt and will generally be easily solvable. The Task Force channeled its efforts to prevent the regulatory framework development process to be side-tracked by not trying to resolve every conceivable issue from the outset. The development of a regulatory framework will be an ongoing regulatory development process as experience is gained

POSITIVE PUBLIC PRESENTATION - Geologic storage of CO_2 is an integral part of a solution that offers the potential for both economic and environmental benefits. Nothing will be achieved by regarding CO_2 geologic storage as a regulatory protection solution to a waste problem.

The intent of this document is to provide to a state or province contemplating adoption of a legal and regulatory framework for the storage of carbon dioxide (CO_2) in geologic media the resources needed to draft a framework that meets the unique requirements of that particular state or province. It is anticipated that a state or province adopting a regulatory framework for CO_2 storage will make changes to the model framework as necessary to conform to state or provincial law. The Task Force therefore envisions that what will result will be a substantially consistent system for the geologic storage of CO_2 regulated at the state and provincial level in conformance with national and international law and protocol. Most importantly, states and provinces are likely to continue to regard CO_2 as a valuable resource that should be managed using resource management frameworks, therefore avoiding the treatment of CO_2 as waste. The Task Force

strongly believes that treatment of geologically stored CO_2 as waste using waste disposal frameworks rather than resource management frameworks will diminish significantly the potential to meaningfully mitigate the impact of CO_2 emissions through geologic storage.

The IOGCC gratefully acknowledges the support of the U.S. Department of Energy, the National Energy Technology Laboratory, the New Mexico Institute of Mining and Technology as well as the critical support of the states and provinces and other entities that so generously contributed their employees' time to the production of this document. In particular, the IOGCC expresses its deep appreciation to Task Force Chairman Lawrence E. Bengal for his outstanding leadership and to the Task Force participants without whom the production of this document would not have been possible. The IOGCC also recognizes the contribution of its legal subcommittee composed of S. Marvin Rogers of Alabama, Cammy Taylor of Alaska, and David Cooney of Texas. The assistance of Lawrence E. Bengal of Illinois, Berry H. "Nick" Tew, Jr. of Alabama and Michael Stettner of California in helping to draft and integrate Task Force comments on the remainder of the guidance document is also gratefully acknowledged.

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Executive Summary

This report is the product of the Interstate Oil and Gas Compact Commission (IOGCC) Task Force on Carbon Capture and Geologic Storage. It is the culmination of a two-phase, five-year effort.[1] This Phase II report takes the form of a Guidance Document for U.S. states and Canadian provinces. Its purpose is to provide to a state or province contemplating adoption of a legal and regulatory framework for the storage of carbon dioxide (CO_2) in geologic media the resources needed to draft a framework that meets the unique requirements of that particular state or province. It is anticipated that a state[2] adopting a regulatory framework for CO_2 storage will make changes to the model framework as necessary to conform to state law. The Task Force therefore envisions that what will result will be a substantially consistent system for the geologic storage of CO_2 regulated at the state and provincial level in conformance with national and international law and protocol.

The Task Force was composed of representatives from IOGCC member states and international affiliate provinces, state and provincial oil and gas agencies, U.S. Department of Energy (DOE)-sponsored Regional Carbon Sequestration Partnerships, the Association of American State Geologists (AASG), and independent experts. Representatives from DOE, the U.S. Environmental Protection Agency (EPA), the U.S. Department of the Interior's Bureau of Land Management (BLM), and the environmental group, Environmental Defense, also participated as observers.

The interest of states in the geologic storage of CO_2 arises because, in addition to conservation, it is among the most immediate and viable strategies available for mitigating the release of CO_2 into the atmosphere. The thirty member states and four Canadian affiliate member provinces of the IOGCC are well suited for regulation of CO_2 storage because of their jurisdiction, experience, and expertise in the regulation of oil and natural gas production. For half a century, most of these states have been the principal regulators of enhanced oil recovery (EOR), as well as natural gas storage and acid gas disposal. They also are strategically well situated for the storage of CO_2. Regulations already exist in these petroleum-producing states covering many of the same issues that need to be addressed in the regulation of CO_2 storage, and consequently serve as adaptable frameworks for CO_2 storage.[3] Several associate member and non-member states of the IOGCC also might be geologically suitable for CO_2 storage and might find the IOGCC Guidance Document valuable in developing a regulatory framework for CO_2 geological storage.

The IOGCC Task Force, funded by the U.S. Department of Energy and its National Energy Technology Laboratory, through a cooperative agreement with the New Mexico Institute of Mining and Technology, has produced for the first time a clear and comprehensive model legal

[1] The first phase concluded with the publication of a Final Report publicly released in early 2005. This phase of the Task Force is henceforth referred to as Phase I.

[2] Although references throughout this Executive Summary are, for the most part, to "state" or "states", it is the intent of the Task Force that the comments and provisions are equally applicable to Canadian provinces. Of course, this would not apply to discussions concerning underground storage rights and the Underground Injection Control Program of the U.S. Safe Drinking Water Act.

[3] States that do not have oil and natural gas production may have experience regulating natural gas storage that will give them an important analogous regulatory experience for purposes of CO_2 geologic storage.

and regulatory regime for the geologic storage of CO_2. As a result of this effort, states and provinces, and indeed other nations using our model, can begin immediately the process of enacting legislation and promulgating regulations enabling CO_2 geologic storage projects. California, New Mexico, North Dakota, Texas, and Wyoming are already in various stages of developing a legal and regulatory framework for geological storage as a result of the work of the Task Force.

The Guidance Document prepared for the states contains, in addition to background information, a paper analyzing property rights issues related to underground space used for geologic storage of carbon dioxide; an overview and explanation of the Model General Rules and Regulations, a Model Statute for Geologic Storage of Carbon Dioxide, and Model General Rules and Regulations.

Development of these model laws and regulations for geologic storage facilitates more states beginning to put in place this critical legal and regulatory infrastructure for CO_2 storage. This should enable timely and responsible development of CO_2 geologic storage projects and, concomitantly, the continued development of CO_2 geologic storage technology.

The Guidance Document does not address the regulatory issues involving CO_2 emissions trading and accreditation for the purpose of securing carbon credits. However, the Task Force strongly believes that development of any future CO_2 emissions trading and accreditation regulatory frameworks should utilize the experiences of the states. The Task Force-proposed Model General Rules and Regulations developed in this report primarily address the regulatory issues related to public health and safety and environmental protections associated with the geologic storage of CO_2. The Task Force concluded that the issue of CO_2 emission trading and accreditation might best be addressed in the marketplace and/or at the federal government level and was beyond the scope of this report.

The Task Force addressed the issue of the content of the CO_2 emission stream proposed to be stored. Given the many technical and regulatory complexities involved in the transportation and geologic storage of varying qualities of CO_2, the Task Force defined CO_2 for purposes of this report as "anthropogenically sourced CO_2 of sufficient purity and quality as to not compromise the safety and efficiency of the reservoir to effectively contain the CO_2." In its Phase I Report, the Task Force defined CO_2 as a direct emissions stream with purity in excess of 95 percent or a processed emission stream with commercial value. However, after much discussion, this definition was modified to accommodate the evolving capture technologies and new research regarding reservoir storage capabilities. The Task Force discussed and is cognizant of the many complexities involving the transportation and injection of CO_2 of varying quality. In addition to quality requirements for transportation of CO2, ultimately it will be up to the State Regulatory Agency to decide what is and what is not suitable to long-term geologic storage.

One of the issues addressed by the Task Force was the most appropriate state regulatory entity to implement the rules and regulations. Because most of the proposed CO_2 geologic storage regulations are based on natural gas storage and oil and gas injection well rules, the Task Force reasoned that states might well conclude that the most logical and best equipped lead agency for implementing and administering regulations effectively and efficiently would be the state oil and gas regulatory agency. However, the Task Force recognizes that other states, especially those without an existing oil and gas regulatory framework, might choose to designate another regulatory agency, such as an environmental agency or public utility commission, as the lead agency for the state.

Most importantly, many states are likely to regard CO_2 as a resource for purposes of enhanced oil recovery projects and consequently will regulate CO_2 utilizing resource management frameworks and will avoid treatment of CO_2 as a waste. The Task Force reiterates a key conclusion reached in its Phase I Final Report -- although contaminants and pollutants such as H_2S, NO_x, SO_2 and other emission stream constituents should remain regulated for public health and safety and other environmental considerations, CO_2, which is generally considered safe and non-toxic and is not now classified at the federal level as a pollutant/waste/contaminant, should continue to be viewed in a manner that allows beneficial uses of CO_2 following removal from regulated emission streams. The Task Force strongly believes that treatment of geologically stored CO_2 as waste using waste disposal frameworks rather than resource management frameworks will diminish significantly the potential to meaningfully mitigate the impact of CO_2 emissions on the global climate through geologic storage.

The Task Force concluded that control of the reservoir and associated pore space used for CO_2 storage is necessary to allow for the orderly development of a storage project. The right to use reservoirs and associated pore space is considered a private property right in the United States, and must be acquired from the owner. Therefore, the Task Force concluded that control of the necessary storage rights should be required as part of the initial storage site licensing to promote orderly development and maximize utilization of the storage reservoir. In the U.S., with the exception of federal lands, the acquisition of these storage rights, which are considered property rights, generally are functions of state law. The Model General Rules and Regulations propose the required acquisition of these storage rights and contemplates use of state natural gas storage eminent domain powers or oil and gas unitization processes to gain control of the entire storage reservoir.

A major issue was how to deal with long-term monitoring and liability issues. The Task Force has proposed a two-stage Closure Period and Post-Closure Period. The Closure Period is defined as that period of time when the plugging of the injection well has been completed and continuing for a defined period of time (10 years unless otherwise designated by the State Regulatory Agency) after injection activities cease and the injection well is plugged. During this Closure Period, the operator of the storage site would be responsible to maintain an operational bond and individual well bonds. The individual well bonds would be released as the wells are plugged. At the conclusion of the Closure Period, the operational bond would be released and the liability for ensuring that the site remains a secure storage site during the Post-Closure Period would transfer to the state.

During the Post-Closure Period, the financial resources necessary for the state or a state-contracted entity to engage in future monitoring, verification, and remediation activities would be provided by a state-administered trust fund. Although other methodologies were reviewed, the Task Force concluded that the most efficient methodology to accomplish these tasks --- and which can be readily fielded --- is to utilize existing frameworks developed by the states for addressing abandoned and orphaned oil and gas wells. Consequently, the Task Force is proposing the creation of an industry-funded and state-administered trust fund as the most effective and responsive "care-taker" program to provide the necessary oversight during the Post-Closure Period. The trust fund would be funded by an injection fee assessed to the site operator and calculated on a per-ton basis, at the point of custody transfer of the CO_2 from the generator to the site operator.

Given that the state is the proposed "care taker" and responsible party during the Post-Closure Period, the Task Force did not address monitoring and related issues in the Model General Rules and Regulations because the state regulatory entity would have the authority to implement any

monitoring, verification, and remediation methods necessary to ensure the security of the storage site. In addition, there are numerous innovative methodologies that could be employed, and many future methodologies might be developed that will be available to ensure the security of the storage site. A full investigation into existing and future methods will require more detailed regulatory research into the implementation of these approaches, which was beyond the scope of this Guidance Document. However, given the availability of the state-administered trust fund model and assuming the reservoir has been adjudged by the State Regulatory Agency (SRA) to be appropriate for long-term storage, adequate resources should be available for the state entity, as care taker, to field these monitoring, verification, and remediation methods.

Finally, there has been considerable discussion at the national level regarding the proper venue for CO_2 geological storage regulation, in particular whether the U.S. EPA might be the best regulatory authority for oversight of storage. Although the UIC Program may be applicable at the discretion of a state program, the current limitations of the UIC program make it applicable only to the operational phase of the storage project. It would therefore appear that given the ownership issue and the proposed long-term "care-taker" role of the states, the states are likely to be best positioned to provide the necessary "cradle to grave" regulatory oversight of geologic storage of CO_2.

Background

The major components of greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and ozone (O_3). These gases account for about 0.04 percent of the atmosphere. They are referred to as "greenhouse gases" because of their effect on the climate.

The "greenhouse" effect results in the capture of radiation from sunlight by preventing radiative heat from reflecting back into space. Although this greenhouse effect is critical in making our planet warm and habitable, the fact that concentrations of CO_2 are increasing yearly raises concern that it could be a primary factor in climate change, or global warming. There is growing interest both within industry and government in the possible opportunities for mitigating the release of carbon into our atmosphere, particularly through carbon capture and geologic storage (CCGS).

Reducing concentrations of anthropogenic[1] greenhouse gases can be accomplished in four basic ways: 1) through energy conservation and energy efficiency; 2) by using technologies involving renewable energy, nuclear power, hydrogen, or fossil fuels containing lower carbon content, e.g., natural gas; 3) by indirect capture of CO_2 after its release into the atmosphere utilizing the oceans or terrestrial sequestration, e.g., reforestation, agricultural practices, etc.; or 4) by carbon capture and geological storage (CCGS), whereby CO_2 is captured and stored in geologic formations through underground injection (instead of being released into the atmosphere).[2]

The thirty member states and four Canadian affiliate member provinces of the IOGCC are well suited for regulation of CO_2 storage because of their jurisdiction, experience, and expertise in the regulation of oil and natural gas production. For half a century, most of these states have been the principal regulators of enhanced oil recovery (EOR), as well as natural gas storage and acid gas disposal. They also are strategically well situated for the storage of CO_2. Regulations already exist in these petroleum-producing states covering many of the same issues that need to be addressed in the regulation of CO_2 storage, and consequently serve as adaptable frameworks for CO_2 storage. Several associate member and non-member states of the IOGCC also might be geologically suitable for CO_2 storage and might find the IOGCC Guidance Document valuable in developing a regulatory framework for CO_2 geological storage.[3]

The IOGCC Task Force on Carbon Capture and Geologic Storage (Task Force) has concluded, however, that while perhaps not necessary, it is advisable for states and provinces to enact a new regulatory framework governing storage of CO_2 in geologic structures. It is that framework which is set forth and explained in this document.

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[1] Anthropogenic is defined in this context as "of, relating to, or influenced by the impact of man on nature." *Webster's New Collegiate Dictionary* 48 (1st ed., G. & C. Merriam Company 1975).

[2] The Department of Energy's Office of Fossil Energy, on behalf of the United States government, has begun an aggressive research program in this regard through its National Energy Technology Laboratory (NETL).

[3] Some states that do not have petroleum production store natural gas and, therefore, have in place natural gas storage regulations. Thus these states, too, have regulations that at least in part cover many of the same issues that need to be addressed in the regulation of CCGS.

The framework developed relies on four analogues, which, in the opinion of the Tas. provide the technological and regulatory basis for storage of CO_2 in geologic media: 1) . occurring CO_2 contained in geologic reservoirs, including natural gas reservoirs; 2) the larg. number of projects where CO_2 has been injected into underground formations for EOR operations; 3) storage of natural gas in geologic reservoirs; and 4) injection of acid gas (a combination of H_2S and CO_2), into underground formations, with its long history of safe operations.

It should also be noted that there exists a significant number of CO_2 EOR and acid gas injection projects in the U.S. and Canada, and, therefore, "storage" of CO_2 is already taking place. Most of this CO_2 is from natural sources, as opposed to anthropogenic or industrial sources (as would be the case with CCGS). CO_2 EOR injection and storage also has the economic benefit of increasing the production of oil. This fact makes it possible that CO_2 EOR projects could be an important vehicle in driving CCGS, at least in its early years. It also could prove the means to build both injection/storage experience, regulatory and otherwise, and provide the physical infrastructure (pipelines/facilities). Together the EOR, natural gas storage, and acid gas injection models provide a technical, economic, and regulatory pathway for long-term CO_2 storage.

However, owing to the scarcity of post-injection CO_2 EOR projects and abandoned natural gas storage fields, inadequate guidance for a long-term CO_2 storage regulatory framework exists. Consequently, a regulatory framework needs to be established to determine long-term liability and to address long-term monitoring and verification of the reservoir and mechanical integrity of wellbores penetrating formations in which CO_2 has been emplaced.

Most importantly, many states are likely to regard CO_2 as a resource for purposes of enhanced oil recovery projects and consequently will regulate CO_2 utilizing resource management frameworks and will avoid treatment of CO_2 as a waste. The Task Force reiterates a key conclusion reached in its Phase I Final Report -- although contaminants and pollutants such as H_2S, NO_x, SO_2 and other emission stream constituents should remain regulated for public health and safety and other environmental considerations, CO_2, which is generally considered safe and non-toxic and is not now classified at the federal level as a pollutant/waste/contaminant, should continue to be viewed in a manner that allows beneficial uses of CO_2 following removal from regulated emission streams. The Task Force strongly believes that treatment of geologically stored CO_2 as waste using waste disposal frameworks rather than resource management frameworks will diminish significantly the potential to meaningfully mitigate the impact of CO_2 emissions on the global climate through geologic storage.

The Task Force reiterates two recommendations contained in its Final Report of January 2005. The first is that the states and provinces actively solicit public involvement in the process as early as possible. The second is that from the outset, the process be clear and transparent. As stated previously, CO_2 is not considered a pollutant and not considered hazardous. Further, it has a long and safe history of being transported, handled, and used in a variety of applications and, thus, the public must be educated on the facts and included in an open regulatory development process.

Part 1: Analysis of Property Rights Issues Related to Underground Space Used for Geologic Storage of Carbon Dioxide

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Several legally recognized interests might exist in property where underground pore space in a particular interval or intervals is to be used for geological storage (GS). Surface owners, mineral owners, lessees of solid minerals, oil and gas lessees, and owners of non-operating interests in production all might have legal rights that could be affected by GS.[1] Because the law recognizes an ownership interest in subsurface pore space, a regulatory program that manages storage (as opposed to water protection) should include clear rules about how these rights will be recognized and protected, as well as a process for assuring that the storer secures the legal property right to store CO_2.

The Interstate Oil and Gas Compact Commission (IOGCC) Geological CO_2 Sequestration Task Force identified three working models that can provide technological and regulatory guidance for GS: (1) injection of CO_2 into underground formations for enhanced oil recovery (EOR) operations, (2) storage of natural gas in geologic reservoirs, and (3) injecting acid gas into underground formations. Legal paradigms associated with storage of natural gas in geologic reservoirs are most closely related to activities expected to occur in GS projects. This paper will discuss how various states address subsurface property rights and liabilities of parties engaged in and affected by activities involving the use of underground pore space for storage, and relate observations from various commentaries.

Case law from various states relating to natural gas storage provides an effective comparison for GS. Even though natural gas is stored for relatively short periods of time and carbon dioxide likely will be stored for very long periods of time, the storage time should not impact

[1] *See* Williams and Meyers, Oil and Gas Law Vol. 1, §222 (Matthew Bender, 2006), for identification of property interests related to storage of natural gas in geologic reservoirs.

determining who has legal interests in the structure used for storage and how a regulatory program should treat them.

Case Law Survey

In Texas, there is no clear general rule on which estate, surface or mineral, possesses ownership of the pore space for storage purposes unless the severance contract expressly specifies. The natural gas storage case law in Texas gives conflicting results because in one case, *Mapco v. Carter*, the mineral owner prevailed[2] while another case, *Emeny v. U.S.*, held in favor of the surface owner.[3] The Texas Supreme Court in *Humble Oil v. West* cited *Emeny*, but the court's holding did not rely on *Emeny*.[4]

In *Mapco*, the court held that the subsurface storage area was owned by the mineral owner, who was entitled to compensation for the use of the storage area.[5] The mineral owner had created the cavern within a salt dome for the purpose of storing natural gas.[6] The cavern walls were constructed of salt, a mineral in Texas (and specifically reserved to the mineral owner in lease documents); therefore, the mineral owner in this case had the exclusive right to the storage.[7] This decision was overruled in part by the Texas Supreme Court, but not on the matter of ownership of the storage space.[8]

In *Emeny*, the Federal Court of Claims, applying Texas law, held that the surface owners retained all property rights, except the mineral rights for oil and gas operations, and the geological subsurface pore space belonged to the surface owners for storage purposes.[9] The natural gas produced elsewhere was transported through the mineral owner's pipeline into the pore space and stored there until the gas was needed.[10] The contracted rights of the mineral owners contained in the oil and gas lease were "for the sole and only purpose of mining and operating for oil and gas and of laying pipe lines . . . to produce, save, and take care of said products."[11] The court reasoned that this language allowed the mineral owner to store gas produced only from the leased premises, not extraneous gas produced elsewhere.[12] *West* cited *Emeny*, stating the surface owner retained the pore space for storage purposes of natural gas.[13] However, ownership of the pore space was conceded to the surface estate, and *West* turned on the issue of whether the

[2]*Mapco, Inc. v. Carter*, 808 S.W.2d 262 (Tex. App.—Beaumont 1991), *rev'd in part*, 817 S.W.2d 686 (Tex. 1991).
[3]*Emeny v. United States*, 412 F.2d 1319 (Ct. Cl. 1969).
[4]*Humble Oil & Refining Co. v. West*, 508 S.W.2d 812 (Tex. 1974).
[5]*Mapco*, 808 S.W.2d at 274.
[6]*Id.* at 264.
[7]*Id.* at 274.
[8]*Mapco, Inc. v. Carter*, 817 S.W.2d 686, 688 (Tex. 1991).
[9]*Emeny*, 412 F.2d at 1323.
[10]*Id.* at 1322.
[11]*Id.* at 1323.
[12]*Id.*
[13]*Humble Oil*, 508 S.W.2d at 815.

pore space could be used for storage purposes prior to all gas being produced from the pore space.[14]

In the current analysis, it is fair to conclude that in Texas, *Mapco* applies only when the storage space is created and comprised of a mineral. Arguably, *Mapco* is inapplicable for GS because the space will be a geological non-mineral pore space. Surface owners in Texas have a solid interest because the *Mapco* court did emphasize that the storage space was comprised of salt and not a geological pore space.[15]

Texas case law on storage ownership seems to indicate that surface owners have a stronger argument for the right to authorize the pore space for storage. However, the case law is uncertain, and the mineral owners have valid arguments that a potential purchaser of the pore space should be required to obtain their consent as well, particularly if the GS project could adversely affect mineral exploration or production. Perhaps the most important aspect of Texas law is that the question of pore space ownership is not clearly settled, highlighting the need for statutory and regulatory clarity.

In a West Virginia Supreme Court of Appeals case, *Tate v. United Fuel*, the judges held that ownership of the storage space belonged to the surface owner because the mineral exception contained in the deed to the surface owner only excepted the right to *produce* minerals.[16] (Emphasis added). The exception in the deed stated, "[t] he oil, gas and brine and all minerals, except coal underlying the surface of the land hereby conveyed are expressly excepted and reserved . . ..."[17] The deed further defined and limited the term mineral as not including "clay, sand, stone, or surface minerals except such as may be necessary for the operation for the oil and gas and other minerals reserved and excepted herein."[18] The court found that limiting of the term "mineral" in the deed exception created a situation in which clay, sand, and stone for purposes other than mining and drilling operations were expressly conveyed to the surface owner.[19]

Tate can be analyzed in more ways than one concerning storage space rights. Surface owners would state that *Tate* should stand for the proposition that once the minerals are extracted and production has ceased, the underground storage space belongs to the surface. Mineral owners' response would be that because of the peculiar language in the deed that limited the general meaning of the term "mineral" the court did not issue a rule that the storage space belongs to the surface owner in every instance. The totality of the circumstances were analyzed in *Tate* and the surface owner prevailed; however, under different circumstances without the term "mineral" being limited, the court might have reached a different decision. Furthermore, it has been

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[14] *Id.*
[15] *Mapco*, 808 S.W.2d at 274.
[16] *Tate v. United Fuel Gas Co.*, 71 S.E.2d 65, 72 (W. Va. 1952).
[17] *Id.* at 67.
[18] *Id.* at 68.
[19] *Id.* at 70-71.

argued, "[a] bout as far as the *Tate* case can be stretched is to say that in West Virginia, an oil and gas owner probably lacks the power to grant storage rights."[20]

In *Ellis v. Arkansas Louisiana Gas*, an Oklahoma case, the Tenth Circuit held that in general the pore space belonged to the surface owner for gas storage purposes; however, in this particular case the mineral owner prevailed because the court found a prescriptive easement.[21] The mineral owner appealed the trial court's ruling concerning the prescriptive easement, but did not challenge the court's determination that the surface owner held the rights to the pore space.[22] Once again, an issue aside from the right to the storage space prevents a general rule being derived. One could assume that had there not been a prescriptive easement, the surface owner would have prevailed.

In *U.S. v. 43.42 Acres of Land*, applying Louisiana law, the court held that after the extraction of minerals, the storage space that remained belonged to the surface owner, and the mineral owner had no claim for compensation.[23] Compensation for the value of the storage space taken by eminent domain is not necessarily determined by the right to produce and mine the minerals.[24] The court further added that regardless of a state's ownership or non-ownership policy pertaining to mineral rights, in no instance should the mineral owner be found to have ownership of the pore space for storage purposes.[25] This decision is important because it involved who was owed compensation for the taking of the storage space, which tells us who under the law had the right to authorize the storage of natural gas. The court seemed clear that in Louisiana the surface owner had the prevailing interest in the storage space in all facets.

In *Department of Transportation v. Goike*, the Michigan Court of Appeals held that the storage space left after the minerals had been excavated belonged to the surface owner.[26] The court reasoned that a mineral owner possesses a right solely to the minerals, not to the other property surrounding the minerals.[27] However, the court made it clear that when native oil or gas remains in the pore space, the mineral owner may preclude the surface owner from using the storage space as "[o]only the surface owner . . . possesses the right to use the cavern for storage of foreign minerals or gas, and then only after [the mineral owners] have extracted the native gas from the cavern."[28] As long as there is no debate whether native gas remains in the pore space, it appears that the approach in Michigan would be to grant the right to authorize storage to the surface owner.

In *Central Kentucky Natural Gas v. Smallwood*, the Kentucky Court of Appeals held that rentals from a storage space must be paid to the mineral owner.[29] The justices added that to reach their

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[20] Williams & Meyers, 1 Oil & Gas Law § 222 (Matthew Bender 2006) (citing Holland, "Underground Storage of Natural Gas: A Legal Overview," 3 Eastern Min. L. Inst. 19 – 1 at 19 – 13 (1982).
[21] *Ellis v. Ark. La. Gas Co.*, 609 F.2d 436, 439 (10th Cir. 1979).
[22] *Id.* at 439.
[23] *United States v. 43.42 Acres of Land*, 520 F.Supp. 1042, 1045 (W.D. La. 1981).
[24] *Id.* at 1044.
[25] *Id.* at 1046.
[26] *Dep't of Transp. v. Goike*, 560 N.W.2d 365, 366 (Mich. Ct. App. 1996).
[27] *Id.* at 365-66.
[28] *Id.* at 366.
[29] *Cent. Ky. Natural Gas Co. v. Smallwood*, 252 S.W.2d 866, 868 (Ky. Ct. App. 1952).

decision clarification was not needed on whether ownership of the pore space belonged to the mineral or surface owner.[30] The court cited the English Rule, which provides that the mineral owner possesses the exclusive right of production as well as the exclusive right to the storage space left after production has ceased.[31] This case was overturned, but only concerning the issue of the stored gas being personal property, and not on the issues of ownership of the pore space or the rentals accruing from the pore space.[32] In opposition to the court's view, surface owners would argue that *Smallwood* was overturned and should not be influential even though it was overturned on grounds not related to pore space ownership.[33] Furthermore, *Smallwood* seems to employ the English rule in regard to ownership and surface owners would argue that the English rule should not be adopted in their jurisdiction, wherever that may be.[34]

While not found in case law, a recent state report from New Mexico provides that deep aquifers would belong to the surface owner for the right to use and authorize them for storage purposes, even though by statute the water in the aquifer is deemed within the public domain.[35] New Mexico's policy towards ownership of pore space is somewhat ambiguous because the state and public entities have the right to use aquifer storage to recharge the aquifer, but the report states that use for other purposes may require compensation. [36] The New Mexico paper indicates that New Mexico would side with the theory that "the subsurface geologic structures – including the pore space as distinct from the mineral estate – belong to the surface property owner . . .."[37]

Commentary

Commentators have varied perspectives on whether the surface or mineral owner should have title to the pore space for gas storage purposes. Elizabeth Wilson and Mark de Figueiredo note that while surface owners in most states prevail in pore space ownership of stored natural gas situations, mineral owners have valid interest as well and it would be prudent for a potential purchaser to secure the rights from both estates.[38] While the commentators' suggestion may be unsatisfactory to potential purchasers who prefer not obtaining consent from both the mineral owner and the surface owner, as well as paying just compensation to both estates, this approach may be highly beneficial in that a potential purchaser will clearly know who to contact and pay to secure the storage space rights without the fear of litigation.

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[30] *Id.* at 868.
[31] *Id.*
[32] *Tex. Am. Energy Corp. v. Citizens Fid. Bank & Trust Co.*, 736 S.W.2d 25, 28 (Ky. 1987).
[33] *Id.*
[34] *Smallwood*, 252 S.W.2d at 868.
[35] *Carbon Dioxide Sequestration: Interim Report on Identified Statutory & Regulatory Issues*, New Mexico Energy, Minerals, Natural Resources Dep't, Oil Conservation Division, pp. 12-13 (June 27, 2007).
[36] *Id.* at 12 – 13.
[37] *Id.* at 10.
[38] Elizabeth J. Wilson & Mark A. de Figueirdo, Geologic Carbon Dioxide Sequestration: An Analysis of Subsurface Property Law, 36 ELR 10114, 21 (2006).

Williams & Meyers suggest four different conclusions regarding subsurface storage of gas.[39]

First, the mineral owner should be granted the exclusive right to the storage space "for all purposes relating to minerals, whether 'native' or 'injected', absent contrary language in the instrument severing such minerals."[40] Under this view, the surface owner should not have any rights or be owed any compensation concerning the pore space unless some use of the surface is needed for the storage,[41] which might be a reasonable approach when the subject is a mineral such as natural gas, but not so reasonable for GS.

Second, the owners of non-operating interests in the production of minerals should not be compensated and their consent should not be needed if the pore space no longer contains minerals; i.e., if the pore space is empty and using the space for storage as the next logical step, then those owners have no interest in the space.[42]

Third, the operating rights owner should not be compensated and consent should not be needed for the right to store natural gas unless the operating rights owner will be negatively impacted by the injection of natural gas.[43]

Finally, the consent of the mineral owner should be required regardless of whether the pore space still contains oil and gas.[44]

Through their conclusions, it appears that Williams & Meyers strongly believe that the dominant interest in the storage space belongs to the mineral owner, not the surface owner. Extrapolating their view, the mineral owner's rights must be secured in every situation where a potential purchaser seeks to acquire the storage space, whereas the surface owner's rights need not be secured unless the use of the surface is required.

Subsurface Trespass

Subsurface Trespass cases offer an indication of how the law treats ownership interests in underground pore space. Based on case law, subsurface trespass is probably a cause of action, and adjacent property owners may be able to prevail if they can demonstrate reasonable and foreseeable damages caused by unauthorized use of their pore space. An analysis comparing secondary oil and gas recovery and hazardous waste case law to the storage of carbon dioxide will be undertaken to help develop reasonable policy for property rights affected by GS.

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[39] Williams & Meyers, 1 Oil & Gas Law § 222 at 334.
[40] *Id.* at 335.
[41] *Id.* at 334.
[42] *Id.* at 336-337.
[43] *Id.* at 337.
[44] *Id.* at 338.

Trespass by EOR

In Texas, a cause of action for damages probably exists for subsurface trespass attributable to secondary recovery operations; however, the issue of subsurface trespass is far from certain because the case law is on both sides of the trespass debate. In *Railroad Commission of Texas v. Manziel*, the Texas Supreme Court held that a permit from the Texas Railroad Commission for oil and gas recovery precludes a trespass cause of action seeking injunctive relief.[45] The issue in *Manziel* was whether the water from the secondary recovery projects would constitute trespassing when it crossed ownership lines.[46] The court announced the "negative rule of capture" whereby "[j]ust as under the rule of capture a land owner may capture such oil and gas as will migrate from adjoining premises . . . so also may [a landowner] inject into a formation substances which may migrate through the structure to the land of others . . . ."[47] In conclusion, the court found that trespass was not a cause of action when the state regulatory body permitted the injection project. The court was without power to issue an injunction sought by the adjacent property owner.[48]

In *Mission Resources v. Garza Energy Trust*, the Corpus Christi Court of Appeals found that Texas recognizes a cause of action for subsurface trespassing for secondary recovery fracture treatment.[49] The court declined to settle the conflict between two previous cases in which one held subsurface trespass by fracture treatment was a cause of action, and the other held there was no cause of action.[50] The decision in *Garza Energy Trust* was appealed and thereafter the Texas Supreme Court granted review. The appellate court's holding was somewhat narrow in that it was not a blanket acceptance of a cause of action for subsurface trespass but limited the cause of action allowed to subsurface trespass for fracture treatment.[51]

The implication of these cases for carbon dioxide storage is debatable. Whether a court would find the storage of carbon dioxide to be a public necessity where adjacent property owners' rights are trumped by the importance of carbon sequestration is uncertain. On the one hand, the storage of carbon dioxide may lower greenhouse gas pollution, but on the other it is questionable whether the potential benefit of lowered greenhouse gas is more important than the property rights of the adjacent property owners. Secondary recovery methods are producing fungible resources in the form of oil and gas whereas the storage of carbon dioxide will not yield fungible resources. Both *Manziel* and *Garza Energy Trust* seem to key on the importance of secondary recovery of oil and gas, and the arguments why a trespass cause of action should not be actionable is based on fungible resources being produced. A regulatory program for GS should include a declaration that the activity is of high public importance.

Trespass by Hazardous Waste Injection

Hazardous waste case law seems to permit a cause of action for subsurface trespass. The Ohio Supreme Court in *Chance v. BP Chemicals* held that regardless of the fact that the defendant was

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[45] *R.R. Comm'n of Tex. v. Manziel*, 361 S.W.2d 560, 568 (Tex. 1962).
[46] *Id.* at 567.
[47] *Id.* at 568.
[48] *Id.*
[49] *Mission Res., Inc. v. Garza Energy Trust*, 166 S.W.3d 301, 310 (Tex. App.—Corpus Christi 2005, review granted.
[50] *Id.* at 310-11.
[51] *Garza Energy Trust*, 166 S.W.3d at 310-11.

operating under a valid permit, trespass as a cause of action is not precluded.[52] Even though ultimately the adjacent property owners lost the suit due to not meeting their burden of proof in proving that trespass had indeed occurred, the court allowed the cause of action.[53]

In *Mongrue v. Monsanto Co.* the Fifth Court of Appeals found that subsurface trespass was a valid cause of action, and stated that a valid permit "does not necessarily bar claims of trespass when authorizing the disposal of waste through injection wells."[54] Subsurface trespass as a cause of action was not a primary issue for the court due to the trespassing claim being dropped,[55] but the court briefly addressed the issue anyway,[56] which might illustrate that the justices wanted to clarify whether there was a cause of action for subsurface trespass. Even though in both cases the party bringing the trespass action did not ultimately prevail for various reasons, subsurface trespass was allowed as a cause of action, which further highlights the law's recognition of property rights in subsurface pore space.

These cases also raise a couple of principles applicable to GS: Plaintiffs in both cases were surface owners, and it was difficult for the plaintiffs to prove they had suffered damages because they could not show that they actually used the subsurface and that the use had been compromised. The inability to show damages played a larger role in the outcome of these subsurface trespass situations cases than whether a cause of action existed in the first place. The law recognized the ownership right in the subsurface, but the plaintiff was not able to show an intended use was compromised or damaged. GS will be a new legitimate use of the subsurface.

Conclusion

The law recognizes an ownership interest in subsurface pore space. Therefore, a regulatory program that manages storage (as opposed to water protection) should include clear rules about how these rights will be recognized and protected as well as a process for assuring that the legal property right to store CO_2 is secured. Based on the foregoing review of subsurface property law, GS statutes and rules would best serve the public by clearly declaring that GS is an important activity for the public interest, clearly identifying the surface owner as the person with the right to lease pore space for storage, while protecting other stakeholders from potential damage attributable to sequestration activities.

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[52] *Chance v. BP Chemicals, Inc.*, 670 N.E.2d 985 (Ohio 1996).
[53] *Id.* at 991.
[54] *Mongrue v. Monsanto Co.*, 249 F.3d 422, 433 n. 17 (5th Cir. 2001).
[55] *Id.* at 425.
[56] *Id.* at 433 n. 17.

Part 2: Overview and Explanation of the Model General Rules and Regulations

Regulations Overview

Overview and Explanation of the Model General Rules and Regulations

The Interstate Oil and Gas Compact Commission's Task Force on Carbon Capture and Geologic Storage has prepared this guidance document. Much of the work has been accomplished by the Task Force's Model Regulations Working Group. The Task Force began its work June 28-30, 2006, in Dallas, Texas, at which time the tasks and responsibilities of the Model Regulations Working Group were defined. The group held three meetings: a kick-off meeting on September 5-8, 2006, in St. Louis, Missouri; a mid-point meeting on October 18, 2006, in Austin, Texas; and a joint wrap-up meeting with the entire Task Force on May 5, 2007, in Point Clear, Alabama.

The guidance document is being prepared for IOGCC member states, including its affiliate member provinces. Although references throughout this document are, for the most part, to "state" or "states", it is the intent of the Task Force that the comments and provisions are equally applicable to Canadian provinces. Specific notation of this is made in both the Model Rules and Regulations and Model Statute attached. Additionally, in Canada, protection of both groundwater resources and deep injection fall entirely within provincial jurisdiction, and there is no federal equivalent of the U.S. Safe Drinking Water Act and the UIC program. Accordingly, regulations may vary from province to province, but their essence is the same and comparable with the U.S. regulations.

This overview section is followed by an appendix consisting of three parts. Appendix I provides a draft model statute for the Geologic Storage of Carbon Dioxide. It contains legislative language necessary to enable a State Regulatory Agency to implement the draft model rules and regulations. Appendix II contains the draft model rules and regulations for geologic CO_2 storage. Taken together, Appendices I and II are the principal deliverable work products of the Task Force. Appendix III contains background material on the "Analysis of the Ownership of Storage Rights Relating to the Storage of CO_2 in Geologic Structures".

The following provides an overview, explanation, and rational for the various sections in Appendix II (Model Rules and Regulations).

Section 1.0. Applicability

The Task Force discussed the applicability of these rules and regulations relative to CO_2 injection in enhanced oil recovery (EOR) projects, as well as to CO_2 injection for storage in non-EOR applications, such as storage in depleted oil and gas reservoirs, deep saline formations, and coal seams. The Task Force does not intend for these rules and regulations to apply to EOR

projects during their normal working life except to the extent an EOR project operator may propose to also permit the EOR project as a CO_2 storage project simultaneously. The Task Force assumed that this conversion generally would occur at the end of the normal operating life of an EOR project. An operator desiring that an EOR project be simultaneously used or converted for CO_2 storage only could submit that project for approval under this program.

Although the potential of developing different sets of rules and regulations to deal with ongoing or former EOR and non-EOR geologic projects was discussed, the Task Force concluded that the similarities were greater than the differences. Consequently, one set of rules and regulations was written to accommodate both scenarios and, thus, these rules and regulations are designed to have general applicability.

The Task Force in its Phase I Final Report did not address the regulatory issues involving CO_2 emissions trading and accreditation for purposes of securing carbon credits. However, the Task Force strongly believes that development of future CO_2 emissions trading and accreditation regulatory frameworks should utilize the experiences of the states and provinces outlined in the Phase I report. Subsequent deliberations of this issue by the Task Force in this current phase (Phase II) concluded that the proposed Model Rules and Regulations should primarily address the regulatory issues related to public health and safety and environmental protections associated with the geologic storage of CO_2. The Task Force believes that the issue of CO_2 emission trading and accreditation might best be addressed either in the marketplace and/or at the federal government level. The Task Force believes that the development and implementation of the necessary economic frameworks to provide for CO_2 emissions trading and accreditation is beyond its scope.

The Task Force also recognizes that even in advance of state adoption of these model rules, it may be necessary to permit and operate experimental and demonstration CO_2 sequestration projects. States are encouraged to advance those projects under existing authority rather than to delay them to await adoption of this program.

Section 2.0. Definitions

The Task Force has provided definitions for many of the terms used throughout the model rules and regulations. The reader should note that several new terms were developed to clearly define the various aspects and stages of a CO_2 storage project. These terms, such as Geological Storage Unit (GSU), CO_2 Storage Project (CSP), and CO_2 Facility (CF), are used extensively throughout the model rules and regulations. Familiarity with these and other definitions will assist the reader in reviewing and applying the model rules and regulations.

"CO_2" is defined in the Model Rules and Regulations. Although the Task Force in its Phase I Report defined CO_2 as a direct emissions stream with purity in excess of 95 percent or a processed emission stream with commercial value, after much discussion this definition was modified to accommodate the evolving capture technologies and new research regarding reservoir storage capabilities. In addition, the Task Force clarified in its definition of "CO_2" that the Model Rules and Regulations only addressed anthropogenically sourced CO_2, which is produced as a byproduct of combustion in the industrial process (including CO_2 generated from oil and gas production and processing operations) and not non-hydrocarbon associated geologically occurring CO_2. The Task Force discussed and is cognizant of the many complexities involving the transportation and injection of CO_2 of varying quality. In addition to

quality requirements for transportation of CO_2, ultimately it will be up to the State Regulatory Agency to decide what is and what is not suitable to long-term geologic storage.

For this report and in the Model Rules and Regulations, the state regulatory agency is referred by the acronym SRA. The Task Force discussed the most appropriate state regulatory entity to implement the rules and regulations, but ultimately each state will have to make its own decision in this regard. Because the analogs for the majority of the proposed regulations are based on natural gas storage and oil and gas injection well rules, states might well conclude that the most logical and best equipped lead agency for implementing and administering regulations in an effective and efficient fashion would be the state oil and gas regulatory agency. However, other states, especially those without an existing oil and gas regulatory framework, might choose to designate another regulatory agency, such as an environmental agency or public utility commission, as the lead agency for the state.

Section 3.0. General Requirements

The Task Force discussed the necessity for state regulatory personnel to have full authority to enter and inspect a CO_2 project facility for compliance with the proposed model rules and regulations. This authority is generally granted to oil and gas regulatory agencies with respect to oil and gas operations and sites. However, as noted, a state may designate a non-oil and gas regulatory agency the responsibility for administering the proposed model rules and regulations. Therefore, the authority to gain access for inspection purposes has been included in the model rules and regulations.

The Task Force also discussed the potential problems that could be encountered in the transfer of ownership of a CO_2 project. The proposed regulations seek to ensure that transfers of ownership encompass all operational liabilities, including transfer of required financial assurances to the state. Further, it is required that the new owner meets all requirements established by the designated state regulatory agency as a qualified CO_2 storage facility permit holder.

Section 4.0. CO_2 Storage Project (CSP) Permit

The Task Force recognizes that a reservoir intended for storage of CO_2 might require the consolidation of all the participating interests in the reservoir before a permit to operate the storage project is issued. The Task Force further recognizes the need for the designated state agency to have the authority to require compulsory joining of all participating interests in the reservoir and such of the surface property necessary for project requirements if the state determines the consolidation of the unit is feasible, necessary, and justifiable under all conditions affecting the unit. These model rules and regulations specify the actions the project applicant may exercise to acquire the rights and interests necessary to operate a CO_2 storage project. Care should be exercised to ensure selection of an appropriate choice of law provision. This typically would involve application of unitization laws to oil and gas reservoirs and eminent domain laws to non-oil and gas producing reservoirs, such as deep saline formations, which would mirror more closely natural gas storage ownership rights. Unitization applies to mineral property rights with respect to oil and gas production covered by an oil and gas lease wherein natural gas storage rights historically have been the property right of the surface owner and therefore subject to eminent domain proceedings. Consequently, the issue arises as to what would happen when an oil and gas EOR project operating under an oil and gas lease terminates and converts to a CO_2 storage project. This issue needs further study to determine whether the ownership rights also

shift to the surface owner and how that potential shift would impact the ability of the EOR project operator to deal seamlessly with the transition from an EOR project to a CO_2 storage project.

The Task Force discussed the need for the designated State Regulatory Agency to have the appropriate permitting authority to require an operator to submit any data necessary to evaluate a proposed CO_2 storage project. The authority should give SRA the ability to require an operator to provide detailed data that, in the judgment of SRA, are pertinent and necessary for the evaluation of a proposed CO_2 storage project. For SRA to perform the evaluation, it is incumbent upon the applicant to submit adequate engineering and geological data along with a CO_2 injection plan that includes a description of mechanisms of geologic confinement, with regard to the ability of that confinement to prevent migration of CO_2 beyond the proposed storage reservoir. This information will be used in conjunction with geological and engineering data and well records that it might have on file to make the necessary evaluation.

The Task Force included within this section a requirement for a public health and safety and emergency response plan, worker safety plan, corrosion monitoring and prevention plan, and a facility and storage reservoir leak detection and monitoring plan. The Task Force engaged in a comprehensive discussion regarding the required level for measurement, monitoring and verification (MMV) of injected CO_2 and its containment within the storage reservoir. While the Task Force recognizes the importance of maintaining containment integrity, given the uncertainties and changing technologies of surface monitoring techniques --- which are the subject of much current research --- the Task Force concluded that monitoring and verification would be accomplished best in the subsurface. Therefore, the Model Rules and Regulations focus primarily on subsurface monitoring of the geologic storage reservoir and overlying formations through the use of observation wells. The Task Force believes that early leak detection in the subsurface of any CO_2 would be the best mechanism to protect public health and safety and the environment and offer sufficient time to address the cause of that leakage. As an example, early detection in the subsurface would allow for the drilling of wells to remediate leakage by producing or capturing leaked CO_2 and re-injecting that CO_2 back into storage. Rather than being overly prescriptive, the Task Force is recommending that the Model Rules and Regulations require the operator to submit a comprehensive monitoring plan for evaluation by SRA that shall be tailored to the specific characteristics of the site prior to issuance of a project permit.

Also included is the requirement for a performance bond that would sufficiently cover well plugging and abandonment, CO_2 injection and/or subsurface observation well remediation, and bond release. The Model Rules and Regulations utilize industry standard methodologies currently employed in regulated activities such as coal mining (regulated under SMCRA) and highway construction to calculate bond amounts. It should be noted that the bond release requirement in this section releases the CO_2 storage operator and generator from future SRA regulatory liability by providing a mechanism for transfer of that liability to the state.

The mechanism for transfer of the long-term liability relating to monitoring and caretaking responsibilities is provided through the creation of a state-administered trust fund. It is proposed that the trust fund be capitalized by a tax or fee paid by the CO_2 storage project operator on a per-ton-of-injected-CO_2 basis. The per-ton cost is yet to be determined. The tax or fee would be deposited in the trust fund and would need to be sufficient to cover the costs related to long-term monitoring, verification, remediation, and capture of CO_2 should any CO_2 escape from the storage reservoir. The Task Force determined that if no trust fund is established to clearly address future liability, the operators would be required to retain the long-term liability, similar

to hazardous waste law requirements, which most likely would have such onerous implications that it could inhibit CO_2 storage projects from occurring.

This section of the Model Rules and Regulations also briefly describes the requirements that must be met to amend an existing permit whenever the CO_2 project operator wishes to enlarge the original areal extent, add other reservoirs, increase the permitted storage reservoir volume, and/or any other significant changes.

Section 5.0. Amalgamation of Rights to Operate GSU

The Task Force concluded, as discussed in Part 3 of this report, that the control of the GSU and associated pore space used for CO_2 storage, is necessary to allow for the orderly development of a CSP. The right to use reservoirs and associated pore space is considered a private property right in the United States, and must be acquired from the owner of those rights. These subsurface rights are treated differently in the enhanced oil recovery and natural gas storage projects used as analogies in this report. This situation might be different in Canada.

In the case of natural gas storage in the United States, the owner of the land surface often holds the underground storage rights. The right to store (storage rights) natural gas in underground reservoirs must be acquired by the operator of a storage project prior to receiving a state permit to operate an underground natural gas storage project. If these rights can not be acquired voluntarily, the operator can request that the state use eminent domain powers to acquire those properties and the associated storage rights necessary for orderly development and operation of the natural gas storage project.

In the case of CO_2 enhanced oil recovery projects, the right to inject CO_2 into the subsurface oil reservoir generally is contained in and part of the oil and gas leasethat would have been obtained to develop the project. During the operation of a CO_2 enhanced oil recovery project (EOR), a certain amount of the injected CO_2 remains in the oil reservoir, and should be considered stored CO_2. Consequently, the right to use an oil reservoir for the associated storage of CO_2 during the operational phase of a CO_2 EOR project would be permissible under an oil and gas lease. However, at the conclusion of a CO_2 EOR project when active oil production ceases and the remaining reservoir capacity is used for CO_2 injection for the purpose of long-term storage, the extension of the underlying oil and gas lease granting this authority has not been clearly enumerated in existing law or in associated case law. It's possible that at the time CO_2 EOR ceases and storage begins, the subsurface rights necessary for storage might need to be acquired, if they had not already been acquired at the beginning of the project. In addition, the potential also could exist that the final CO_2 storage phase of a CO_2 EOR project might not necessarily end further oil production. A long-term CO_2 "soaking" phase could be contemplated, followed by reactivation of another phase of oil production, before the final storage of CO_2 in the reservoir is initiated. This "soaking" phase might be covered by the initial oil and gas lease; however, the necessary storage rights eventually will need to be acquired as part of the final storage phase.

The Task Force concluded that control of the necessary storage rights should be required as part of the initial GSU site licensing to promote orderly development and maximize utilization of the GSU. In the U.S., with the exception of federal lands, the acquisition of these storage rights, which are considered property rights, generally are functions of state law. The Model Rules and Regulations propose the required acquisition of these storage rights and contemplate use of state natural gas eminent domain powers or oil and gas unitization processes to gain control of the entire GSU. The situation might be different in Canada.

If the proposed CSP Operator is unable to acquire the necessary subsurface rights covering the entire proposed GSU, the CSP Operator could elect to use the authority granted by this program to gain control of the GSU. Although the authority which allows the CSP Operator to gain control of the GSU is a state power, the process of eminent domain or unitization might reside in a state agency not involved with the initial site licensing process, resulting in two simultaneous processes. The Model Rules and Regulations contemplate these regulatory processes occurring at the same time, and with respect to the public hearing required in each of the processes (eminent domain and site licensing) and given that the required public hearings could occur in multiple agencies, the Task Force recommends that the regulatory agencies combine the hearings to facilitate an efficient and streamlined process. In addition, the state regulatory agencies involved with the hearings will need to determine who has standing at the hearing; such as whether only affected property owners have standing to object (which would be in the case of an eminent domain or unitization hearing) or if non-property ownership interests also have standing to object during the permit licensing phase of a consolidated hearing. To streamline the hearing process, these agencies should contemplate determining what would constitute grounds for a legitimate objection.

The Task Force recognizes that a state might develop alternative mechanisms to acquire property rights. Possibilities include the development of a unitization process to address subsurface interests while using eminent domain process for surface interests. The Task Force is less concerned about what mechanism is used and more concerned that all necessary property rights be acquired by valid, subsisting and applicable state law.

Section 6.0. CSP Well Permits

These Model Rules and Regulations specify the procedures for permitting and operating CSP wells to safeguard life, health, property, and the environment. The regulations specify design standards to ensure that injection wells are constructed to prevent the migration of CO_2 into other than the intended injection zone. Design standards include requirements for the placement of sealing materials within the annular space between well casing and the borehole to ensure fluids do not migrate vertically; installation of tubing and packer and wellhead components; mechanical integrity testing of the casing; and the witnessing and verification of mechanical integrity testing by SRA.

The regulations in this section also detail the well permit amendment process to ensure any modifications or changes to well operations, such as a change in storage zone or a change in injection rates and pressures, remain in compliance with permit conditions.

Section 7.0. CO_2 Storage Project Operational Standards

This section details the operational standards and requirements with which CO_2 storage project operators must comply in implementing the approved safety, corrosion monitoring and prevention, leak detection, and reporting programs approved in the permit issued by SRA.

Section 8.0. Reporting Requirements

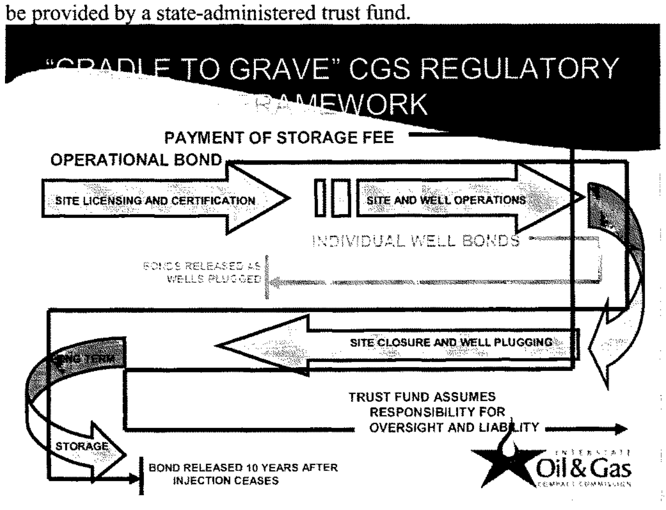
This section of the regulations specifies the reporting requirements that serve to demonstrate and document that CO_2 storage projects and associated wells are operated in accordance with all

approved operating parameters and procedures, including limitations on injection pressures and temperatures; prescribed chemical constituents and composition of the CO_2; status and projections of storage response and capacity; monitoring of corrosion and corrosion prevention plans and/or all other operating parameters and procedures as specified in the CO_2 project permit issued by SRA. Quarterly and annual reports are required.

Section 9.0 CSP Closure

Closure is proposed to be divided into a Closure Period and Post-Closure Period. The Closure Period is defined as that period of time when the plugging of the injection wells (excluding wells to be used as observation wells as agreed upon between the CSP Operator and the SRA) is completed and continuing until a future date is reached, defined as some period of time (10 or 29 years, etc.) after injection activities and the injections wells are plugged. During this Closure Period, the operator of the CSP would be the responsible party and be required to maintain the CSP operational bond and individual or blanket well bonds specified in Section 4. The individual well bonds will be released as the wells are plugged. At the conclusion of the Closure Period, the operational bond would be released and the liability for ensuring that the CSP remains a secure storage site during the Post-Closure Period would transfer to the state.

During the Post-Closure Period the financial resources necessary for the state or a state-contracted entity to engage in future monitoring, verification, and remediation activities would be provided by a state-administered trust fund.



The Task Force also reviewed other methodologies of Post-Closure monitoring, verification, remediation, and liability, including:

(1) The Texas FutureGen model: a legislative assumption of liability by the state with no funding mechanism (which at this time only applies to the single FutureGen prototype plant);

(2) A governmental insurance fund along the lines of the federal flood insurance program;
(3) A private insurance program funded through premiums;
(4) The Price-Anderson Act analog, which would protect the liability of the CSP operator and the CO_2 generators;
(5) The Federal Superfund model under CERCLA;
(6) The Federal Oil Pollution Act of 1990 Model;
(7) Acquisition by the state of the storage rights through private purchase of the storage rights from private owners;
(8) The Resource Conservation and Recovery Act (RCRA)[1] model where the generators of the CO_2 would be the responsible party.

Although other methodologies were reviewed, the Task Force concluded that the most efficient methodology to accomplish these tasks --- and which can be readily fielded --- is to utilize existing frameworks developed by the states for addressing abandoned and orphaned oil and gas wells. The Task Force is proposing the creation of an industry-funded and state-administered trust fund as the most effective and responsive "care-taker" program to provide the necessary oversight during the Post-Closure Period. The trust fund would be funded by an injection fee assessed to the CSP Operator and calculated on a per ton basis, at the point of custody transfer of the CO_2 from the generator to the CSP Operator.

Given the state is the proposed "care taker" entity and responsible party during the Post-Closure Period, the Task Force did not propose Model Rules and Regulations because the state regulatory entity would have the authority to implement any monitoring, verification, and remediation methods necessary to ensure the security of the CSP. In addition, there are numerous innovative methodologies that could be employed, and many future methodologies might be developed that will be available to ensure the security of the CSP. A full investigation into existing and future methods will require more detailed regulatory research into the implementation of these approaches, which was beyond the scope of this guidance document. However, given the availability of the state-administered trust fund model and assuming the reservoir has been adjudged by the State Regulatory Agency (SRA) to be appropriate for long-term storage, adequate resources should be available for the state entity, as care taker, to field these monitoring, verification, and remediation methods. No model regulations were proposed, but following is a list of items the state entity should consider in an ongoing monitoring program during the Post-Closure Period:
(1) Measurement of pressure and fluid samples from observation wells;
(2) Seismic mapping of plume location and movement;
(3) Drilling of additional monitoring wells;
(4) Updating of simulation models that predict CO_2 volume placement and movement;
(5) Installation and monitoring of potential surface monitoring instrumentation;
(6) Ongoing monitoring of human activity to ensure public awareness during construction activities in the area of the CSP;
(7) Monitoring of biological indicators; and
(8) Maintaining adequate records regarding the location and performance of the CSP for state, public and industry use.

[1]42 U.S.C. §§ 6901 et seq. (1976).

Appendices

Appendix I: Model Statute for Geologic Storage of Carbon Dioxide

Model Statute [1]

GEOLOGIC STORAGE OF CARBON DIOXIDE

Section 1. Legislative declaration; jurisdiction. [2]

(a) The Legislature of the State of ________ declares that (1) the geologic storage of carbon dioxide will benefit the citizens of the state and the state's environment by reducing greenhouse gas emissions; (2) carbon dioxide is a valuable commodity to the citizens of the state; and (3) geologic storage of carbon dioxide gas may allow for the orderly withdrawal as appropriate or necessary, thereby allowing carbon dioxide to be available for commercial, industrial, or other uses, including the use of carbon dioxide for enhanced recovery of oil and gas (EOR).

(b) The State Regulatory Agency shall have the jurisdiction and authority over all persons and property necessary to administer and enforce effectively the provisions of this article concerning the geologic storage of carbon dioxide. In exercising such jurisdiction and authority granted to it, the State Regulatory Agency may conduct hearings and promulgate and enforce rules, regulations, and orders concerning geologic storage of carbon dioxide.

Section 2. Definitions.

(a) ***Carbon dioxide.*** Anthropogenically sourced carbon dioxide of sufficient purity and quality as to not compromise the safety and efficiency of the reservoir to effectively contain the carbon dioxide.

(b) ***Oil or gas.*** Oil, natural gas, or gas condensate.

(c) ***Reservoir.*** Any subsurface sedimentary stratum, formation, aquifer, or cavity or void (whether natural or artificially created) including oil and gas reservoirs, saline formations and coal seams, suitable for or capable of being made suitable for the injection and storage of carbon dioxide therein.

(d) ***Storage facility.*** The underground reservoir, underground equipment, and surface buildings and equipment utilized in the storage operation, excluding pipelines used to transport the carbon dioxide from one or more capture facilities to the storage and injection site. The underground reservoir component of the storage facility includes any necessary and reasonable areal buffer and subsurface monitoring zones designated by the State Regulatory Agency for the purpose of ensuring the safe and efficient operation of the storage facility for the storage of carbon dioxide and shall be chosen to protect against pollution, invasion, and escape or migration of carbon dioxide.

(e) ***Storage operator.*** Any person, corporation, partnership, limited liability company, or other entity authorized by the State Regulatory Agency to operate a storage facility.

(f) ***Geologic storage.*** Permanent or short-term underground storage of carbon dioxide in a reservoir.

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[1] Canadian provinces should replace "state" with "province" as appropriate.

[2] The purpose of this section is to make clear that the primary goal is to permanently store carbon dioxide to mitigate its impact on global climate change; however, given the commodity status of carbon dioxide, under certain circumstances states need statutory authority to regulate withdrawal of previously stored carbon dioxide for EOR and other uses that do not involve release to the atmosphere.

Section 3. State Regulatory Agency approval; recordation or order, certificate of operation of storage facility.

(a) The use of a reservoir as a storage facility for carbon dioxide is hereby authorized, provided that the State Regulatory Agency shall first enter an order, after public notice and hearing, approving such proposed geologic storage of carbon dioxide and designating the horizontal and vertical boundaries of the geologic storage facility. In order to establish a storage facility for carbon dioxide, the State Regulatory Agency shall find as follows:

(1) That the storage facility and reservoir are suitable and feasible for the injection and storage of carbon dioxide;

(2) That a good faith effort has been made to obtain the consent of a majority of the owners having property interests affected by the storage facility and that the operator intends to acquire any remaining interest by eminent domain or otherwise allowed by statute;

(3) That the use of the storage facility for the geologic storage of carbon dioxide will not contaminate other formations containing fresh water or oil, gas, coal, or other commercial mineral deposits; and

(4) That the proposed storage will not unduly endanger human health and the environment and is in the public interest.

(b) Upon the State Regulatory Agency's issuance of an order of approval as set forth above, said order, or a certified copy thereof, shall be filed for record in the probate court [or other appropriate entity of jurisdiction where land records are filed] of the county or counties in which the storage facility is to be located.

(c) Prior to commencing injection of carbon dioxide, the storage operator shall record in the county or counties in which the storage facility is located, and with the State Regulatory Agency, a certificate, entitled "Certificate of Operation of Storage Facility," which shall contain a statement that the storage operator has acquired by eminent domain or otherwise all necessary ownership rights with respect to the storage facility, and the date upon which the storage facility shall be effective.

(d) If any depleted pool for any previously established field(s) or producing unit(s) for hydrocarbons is contained within the boundaries of the storage facility, the State Regulatory Agency may in its order of approval for such storage facility order that such field(s) or unit(s) shall be dissolved as of the effective date of the storage facility as set forth in the Certificate of Operation of Storage Facility.

Section 4. Protection against pollution and escape of carbon dioxide.

The State Regulatory Agency shall issue such orders, permits, certificates, rules and regulations, including establishment of appropriate and sufficient financial sureties as may be necessary, for the purpose of regulating the drilling, operation, and well plugging and abandonment and removal of surface buildings and equipment of the storage facility to protect the storage facility against pollution, invasion, and the escape or migration of carbon dioxide.

Section 5. Eminent domain or other applicable statutory authority. [3]

(a) Any storage operator is hereby empowered, after obtaining approval of the State Regulatory Agency as herein required, to exercise the right of eminent domain provided by law, to acquire all surface and subsurface rights and interests necessary or useful for the purpose of

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[3] Although the Task Force determined that the most likely mechanism for amalgamating the property rights (surface or subsurface) necessary for the permitting and operation of a carbon dioxide storage facility is eminent domain, the Task Force also recognizes that particular states might have other mechanisms more appropriate for this purpose, e.g., unitization. It is important to note, however, that the Task Force has concluded that the amalgamation of property rights is absolutely necessary to properly permit, construct and operate a carbon dioxide storage project. Further, the eminent domain power outlined in this model statute is an eminent domain authority solely authorized within the carbon dioxide storage statute and is in addition to any eminent domain authority that may already be possessed by a non-government entity such as a public utility.

operating the storage facility, including easements and rights-of-way across lands for transporting carbon dioxide among facilities constituting said storage facility. Such power shall be exercised under the procedure provided by other applicable laws relating to eminent domain. [4]

(b) No rights or interests in storage facilities acquired for the injection, storage, and state authorized withdrawal of carbon dioxide by a party who has obtained an order from the State Regulatory Agency under the provisions of Section 2, shall be subject to the exercise of the right of eminent domain authorized by the article. The State Regulatory Agency, however, may reopen an earlier order for the purpose of balancing the interests of both projects. Nothing in this article shall alter or revise any power of eminent domain that may exist under any other authority.

(c) The right of eminent domain granted in this section shall not prevent the right of the owner of said land or of other rights therein to drill through the storage facility so appropriated in such manner as shall comply with the rules and regulations of the State Regulatory Agency issued for the purpose of protecting the storage facility against pollution or invasion and against the escape or migration of carbon dioxide. Furthermore, the right of eminent domain granted in this section shall not prejudice the rights of the owners of said lands or other rights or interests therein as to all other uses not acquired for the storage facility.

Section 6. Establishment of Carbon Dioxide Storage Facility Trust Fund. [5]

There is hereby established the Carbon Dioxide Storage Facility Trust Fund to be administered by the State Regulatory Agency. There is hereby levied on the storage operator [6] a tax or fee equal to $------- on each ton of carbon dioxide injected for storage for the purpose of funding the Carbon Dioxide Geologic Storage Trust Fund. The Trust Fund shall be utilized solely for long-term monitoring of the site, including remaining surface facilities and wells, remediation of mechanical problems associated with remaining wells and surface infrastructure, repairing mechanical leaks at the site, and plugging and abandoning remaining wells under the jurisdiction of the State Regulatory Agency for use as observation wells. The Trust Fund shall be administered by the State Regulatory Agency.

Section 7. Administration expenses for this article relating to geologic storage of carbon dioxide.

For the purpose of funding the administration and enforcement of these laws relating to geologic storage of carbon dioxide by the State Regulatory Agency during the operational phase of the storage facility, and for the purpose of compliance inspections including the expense of inspecting, testing, and monitoring the geologic storage facility, there is hereby levied on the storage operator a per ton tax or fee collected as a percentage of the fee or tax levied in Section 6 above. The State Regulatory Agency may utilize these monies as it deems appropriate solely for administering and enforcing this article.

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[4] In the exercise of the power of eminent domain, a state might consider allowing a storage operator the right of early entry if such right is not otherwise specifically authorized in those circumstances where the eminent domain process may be lengthy.

[5] The purpose of the Trust Fund will be to provide the State Regulatory Agency with sufficient funds to provide long-term "caretaking" of the facility and to allow the operator and the producer of carbon dioxide the necessary regulatory certainty that ultimately includes release from liability. Based on a particular state's requirements, each state will have to determine the methodology used to provide adequate funding, which would need to include a detailed analysis of the costs anticipated over the lengthy project "caretaking" time frames contemplated.

[6] It is contemplated that the tax or fee will be assessed to and paid by the state-permitted entity. However, in all likelihood the facility operator would recover the tax or fee from the generator of the carbon dioxide.

Section 8. Liability Release. [7]

Ten years,[8] or other time frame established by rule, after cessation of storage operations, the State Regulatory Agency shall issue a Certificate of Completion of Injection Operations, upon a showing by the Storage Operator that the reservoir is reasonably expected to retain mechanical integrity and remain emplaced, at which time ownership to the remaining project including the stored carbon dioxide transfers to the state. Upon the issuance of the Certificate of Completion of Injection Operations, the operator and all generators of any injected carbon dioxide shall be released from all further State Regulatory Agency liability associated with the project. In addition, upon the issuance of the Certificate of Completion of Injection Operations, any performance bonds posted by the operator shall be released and continued monitoring of the site, including remediation of any well leakage, shall become the responsibility of the Carbon Dioxide Storage Facility Trust Fund.

Section 9. Cooperative Agreements.

The State Regulatory Agency is authorized to enter into cooperative agreements with other governments or government entities for the purpose of regulating carbon dioxide storage projects that extend beyond state regulatory authority under this article. [9]

Section 10. Enhanced hydrocarbon recovery operations. [10]

The State Regulatory Agency is expressly authorized to develop rules to allow conversion of an existing enhanced recovery operation into a storage facility. Upon approval of the conversion of such a project the provisions of this article shall apply. Nothing in this article shall apply to the use of carbon dioxide as a part of or in conjunction with any enhanced recovery methods where the sole purpose of the project is enhanced oil or gas recovery.

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[7] The intent of this section is to provide a methodology whereby the operator and the generator of the carbon dioxide can be released from future liability. This aspect of the statute will allow for regulatory certainty by the industry and help to promote the development of carbon dioxide storage.

[8] While the Task Force decided that a 10-year time frame prior to release of the operator and carbon dioxide generator from liability would allow adequate time to determine that there are no known issues as to the integrity of the storage facility, the amount of time prior to release of the operator and generator from liability is ultimately a state decision. Time periods ranging from 3 to 10 years were discussed. The Task Force, however, felt that a release of operator and generator liability would be necessary to encourage timely development.

[9] Such an agreement might allow the state that hosts the injection well to take the lead in permitting and might allow other affected states the right to "certify" a project in much the same way as is done under the current program under Section 404 of the Clean Water Act in the United States.

[10] The purpose of this section is to ensure that the State Regulatory Agency will have authority (i) to provide a flexible regulatory framework that will allow a carbon dioxide EOR project to convert to a carbon dioxide storage project or vice versa or (ii) to develop a regulatory framework to allow EOR and a storage project to occur simultaneously.

Appendix II: Model General Rules and Regulations

General Rules and Regulations

GEOLOGIC STORAGE OF CARBON DIOXIDE

Section 1.0. Applicability

The following rules and regulations shall govern the geologic storage of CO_2 in geologic reservoirs. These rules apply to all CO_2 storage operations occurring within the territorial jurisdiction of the state. [1]

Section 2.0. Definitions

The following terms, as used in these regulations for geologic CO_2 storage facilities, shall have the following meanings:
(a) **CO_2** means anthropogenically sourced carbon dioxide of sufficient purity and quality as to not compromise the safety and efficiency of the reservoir to effectively contain the CO_2.
(b) **CO_2 Facility** (CF) means, all surface and subsurface infrastructure including wellhead equipment, down hole well equipment, compression facilities and CO_2 flow lines from injection facilities to wells within the Geological Storage Unit (GSU), monitoring instrumentation, injection equipment, and offices. CF does not include the main transportation pipeline to the GSU and pump stations along that pipeline.
(c) **CO_2 flow lines** means the pipeline transporting the CO_2 from the CF injection facilities to the wellhead.
(d) **CO_2 injection well** means a well used to inject CO_2 into and/or withdraw CO_2 from a reservoir.
(e) **CO_2 Storage Project** (CSP) means the project in its entirety, including CF and GSU.
(f) **CSP Closure Period** means that period of time (10 years unless otherwise designated by the State Regulatory Agency {SRA}) from the permanent cessation of active CSP injection operations until the expiration of the CSP performance bond, unless monitoring efforts following the operational period demonstrate to SRA that a different time frame is appropriate.
(g) **CSP Operational Period** means the period of time in which injection occurs.
(h) **CSP Operator** means that entity required by SRA to hold the permit.
(i) **CSP Permit** means the permit issued by the state or province to operate a CSP.
(j) **CSP Post Closure Period** means that period of time after the release of the CSP performance bond.
(k) **Formation fracture pressure** means the pressure, measured in pounds per square inch, which, if applied to a subsurface formation, will cause that formation to physically fracture.
(l) **Fresh water** means USDW unless otherwise defined by SRA.
(m) **Geological Storage Unit** (GSU) means the reservoir used by an entity that holds the SRA permit authorizing CO_2 injection activities.
(n) **Geologist or Engineer** means a person qualified by education and experience to be recognized as an expert by SRA.

[1] This document is drafted using the word "state". Canadian provinces should substitute either the word "province" or "provincial" as required. Similarly, Canadian provinces should substitute as appropriate the definitions of Underground Sources of Drinking Water (USDW) and Safe Drinking Water Act (SDWA) here and in the following text.

(o) **Reservoir** means for the purposes of these rules any subsurface sand, stratum, formation, or cavity or void (whether natural or artificially created), including oil and natural gas reservoirs, saline formations and coal seams, suitable for or capable of being made suitable for the injection and safe and efficient storage of CO_2 therein.
(p) **SRA** means the State Regulatory Agency designated by the state for purposes of these regulations.
(q) **Subsurface observation well** means a well either completed or re-completed for the purpose of observing subsurface phenomena, including the presence of CO_2, pressure fluctuations, fluid levels and flow, temperature, and in situ water chemistry.
(r) **Underground Sources of Drinking Water** (USDW) means:
(1) An aquifer or its portion:
(A) Which supplies any public water system; or
(B) Which contains a sufficient quantity of ground water to supply a public water system; and
(i) Currently supplies drinking water for human consumption; or
(ii) Contains fewer than 10,000 mg/l total dissolved solids; and
(2) An aquifer or its portion which is not an exempted aquifer as defined in the U.S. Safe Drinking Water Act [2] (SDWA).

Section 3.0. General Requirements

Section 3.1. Site Access

(a) SRA shall, at all times, have access to and may inspect all CO_2 storage operations and records for the purpose of determining that performance is being conducted in accordance with the CSP permit, or the requirements pursuant to Sections 3.0–9.0, or in accordance with the orders of SRA approving CO_2 storage operations.

Section 3.2. CSP Permit Transfer

(a) Transfer Notification by Transferor: The CSP operator shall notify SRA, in writing, in such form as SRA may direct, of the sale, assignment, transfer, conveyance, exchange, or other disposition of the CSP by the operator of the CSP as soon as is reasonably possible, but in no event later than the date that the sale, assignment, transfer, conveyance, exchange, or other disposition becomes final. The operator shall not be relieved of responsibility for the CSP until SRA acknowledges the sale, assignment, transfer, conveyance, exchange, or other disposition, in writing, and the person or entity acquiring the CSP is in compliance with all appropriate requirements. The operator's notice shall contain all of the following:
(1) The name and address of the person or entity to whom the CSP was or will be sold, assigned, transferred, conveyed, exchanged, or otherwise disposed.
(2) The name and location of the CSP, and a description of the land upon which the CSP is situated.
(3) The date that the sale, assignment, transfer, conveyance, exchange, or other disposition becomes final.
(4) The date when possession was or will be relinquished by the operator as a result of that disposition.
(b) Transfer Notification by Transferee: Every person or entity that acquires the right to operate a CSP, whether by purchase, transfer, assignment, conveyance, exchange, or other disposition, shall, as soon as it is reasonably possible, but not later than the date when the acquisition of the

[2] 42 U.S.C. § 300(h)(1) (1976).

CSP becomes final, notify SRA in writing, of the person's or entity's operation. The acquisition of a CSP shall not be recognized as complete by SRA until the new operator provides all of the following material:

(1) The name and address of the person or entity from which the CSP was acquired.
(2) The name and location of the CSP, and a description of the land upon which the CSP is situated.
(3) The date when the acquisition becomes final.
(4) The date when possession was or will be acquired.
(5) Performance bonds required by Geologic CO_2 Storage regulations 4.0 (10) and (11).

Section 4.0. CO_2 Storage Project (CSP) Permit

Section 4.1. CSP Permit Requirements

(a) No CSP shall be constructed or operated without:

(1) The CSP operator holding the necessary and sufficient property rights for construction and operation of the CSP. The CSP operator is deemed to be holding such rights for any individual property to the extent that the applicant has initiated unitization or eminent domain proceedings related to that property and thereby gained the right of access to the property. The intention of the CSP operator to employ unitization or eminent domain to acquire property rights shall be included in public notice as defined in Section 5.0; and
(2) Obtaining a license from SRA.

(b) Application for CSP permit shall be submitted to SRA as required and shall include the following:

(1) A current site map showing the boundaries of the GSU, the location and well number of all proposed CO_2 injection wells, including any subsurface observation wells and the location of all other wells including cathodic protection boreholes and the location of all pertinent surface facilities within the boundary of the CSP;
(2) A technical evaluation of the proposed CSP, including but not limited to, the following:

(A) The name of the GSU;
(B) The name, description, and average depth of the reservoir or reservoirs to be utilized for geologic CO_2 storage;
(C) A geologic and hydrogeologic evaluation of the GSU, including an evaluation of all existing information on all geologic strata overlying the GSU including the immediate caprock containment characteristics and all designated subsurface monitoring zones. The evaluation shall include any available geophysical data and assessments of any regional tectonic activity, local seismicity and regional or local fault zones, and a comprehensive description of local and regional structural or stratigraphic features. The evaluation shall focus on the proposed CO_2 storage reservoir or reservoirs and a description of mechanisms of geologic confinement, including but not limited to rock properties, regional pressure gradients, structural features, and absorption characteristics with regard to the ability of that confinement to prevent migration of CO_2 beyond the proposed storage reservoir. The evaluation shall also identify any productive oil and natural gas zones occurring stratigraphically above, below, or within the GSU and any freshwater-bearing horizons known to be developed in the immediate vicinity of the GSU. The evaluation shall include exhibits and plan view maps showing the following:

(i) All wells, including but not limited to, water, oil, and natural gas exploration and development wells, and other man-made subsurface

structures and activities, including coal mines, within one mile of the outside boundary of the GSU;
(ii) All manmade surface structures that are intended for temporary or permanent human occupancy within the GSU and within one mile of the outside boundary of the GSU;
(iii) Any regional or local faulting;
(iv) An isopach map of the proposed CO_2 storage reservoir or reservoirs;
(v) An isopach map of the primary and any secondary containment barrier;
(vi) A structure map of the top and base of the storage reservoir or reservoirs;
(vii) Identification of all structural spill points or stratigraphic discontinuities controlling the isolation of stored CO_2 or associated fluids;
(viii) An evaluation of the potential displacement of in situ water and the potential impact on groundwater resources, if any; and
(ix) Structural and stratigraphic cross-sections that describe the geologic conditions at the reservoir.

A geologist or engineer shall conduct the geologic and hydrogeologic evaluation required under this paragraph. As appropriate, existing geologic, geophysical, or engineering data available on the proposed GSU may be incorporated into the evaluation;
(D) A review of the data of public record for all wells within the CSP Permit, which penetrate the reservoir or primary and/or secondary seals overlying the reservoir designated as the CO_2 storage reservoir, and those wells that penetrate the geologic CO_2 storage reservoir within one mile, or any other distance as deemed necessary by SRA, of the boundary of the GSU. This review shall determine if all abandoned wells have been plugged in a manner that prevents the movement of CO_2 or associated fluids from the geologic CO_2 storage reservoir. A geologist or engineer shall conduct the review required under this paragraph;
(E) The proposed calculated maximum volume and areal extent for the proposed GSU using a method acceptable to and filed with SRA;
(F) The proposed maximum bottom hole injection pressure to be utilized at the reservoir. The maximum allowed injection pressure, measured in psig, shall be no greater than 90 percent or other injection pressures approved by SRA of the formation fracture pressure as determined by a step-rate test or other method approved by SRA. The GSU shall not be subjected to injection pressures in excess of the calculated fracture pressure even for short periods of time. Higher operating pressures may be allowed if approved by SRA. The application, if approved by SRA, shall be subject to any conditions established by SRA;
(G) The proposed maximum long-term GSU pressure and the necessary technical data to support the proposed GSU storage pressure request.

(3) The extent of the CO_2, determined by utilizing all available geologic and reservoir engineering information, and the projected response and storage capacity of the GSU;
(4) A detailed description of the proposed CF public safety and emergency response plan. The plan shall detail the safety procedures concerning the facility and residential, commercial, and public land use within one mile, or any other distance as deemed necessary by SRA, of the outside boundary of the CSP Permit. The public safety and emergency response procedures shall include contingency plans for CO_2 leakage from any well, flow lines, or other permitted facility. The public safety and emergency response procedures also shall identify specific contractors and equipment vendors capable of providing necessary services and equipment to respond to such CO_2 injection well leaks or loss of containment from CO_2 injection wells or the CO_2 storage reservoir.

These emergency response procedures should be updated as necessary throughout the operational life of the permitted storage facilities.

(5) A detailed worker safety plan that addresses CO_2 safety training and safe working procedures at the CF;

(6) A corrosion monitoring and prevention plan for all wells and surface facilities;

(7) A CF leak detection and monitoring plan for all wells and surface facilities. The approved leak detection and monitoring plan shall address:

(A) Identification of potential release to the atmosphere;

(B) Identification of potential degradation of groundwater resources with particular emphasis on USDWs; and

(C) Identification of potential migration of CO_2 into any overlying oil and natural gas reservoirs.

(8) A GSU leak detection and monitoring plan utilizing subsurface observation wells to monitor any movement of the CO_2 volume outside of the permitted GSU. This may include the collection of baseline information of CO_2 background concentrations in groundwater, surface soils, and chemical composition of in situ waters within the GSU. The approved subsurface leak detection and monitoring plan shall be dictated by the site characteristics as documented by materials submitted in support of the application with regard to CO_2 containment and address:

(A) Identification of potential release to the atmosphere;

(B) Identification of potential degradation of groundwater resources with particular emphasis on USDWs; and

(C) Identification of potential migration of CO_2 into any overlying oil and natural gas reservoirs.

(9) The proposed well casing and cementing program detailing compliance with Section 6.0;

(10) A performance bond covering the surface facility to SRA in an amount established by SRA. The amount of the bond shall be sufficient to provide financial assurance to SRA to cover the abandonment of the CSP or remediation of facility leaks should the CSP operator not perform as required or cease to exist. The CSP bond shall be maintained for 10 years after closure of the facility in accordance with Section 9.0 below;

(11) A performance bond for each CO_2 injection and subsurface observation well to SRA in an amount established by SRA. The amount of the bond shall be sufficient to provide financial assurance to SRA to cover the plugging and abandonment or the remediation of a CO_2 injection and/or subsurface observation well should the CSP operator not perform as required in accordance with the permit or cease to exist;

(12) The payment of the application fee;

(13) Any other information that SRA requires; and

(14) A closure plan.

Section 4.2. Amendment to CSP Permit

(a) The following changes to the original CSP permit conditions will require compliance with all the provisions of Section 4.1 above:

(1) Any change in the original areal extent of the CSP permit;

(2) Utilization of other reservoirs not specified in the original CSP permit;

(3) Any proposed increase in the permitted CO_2 storage volume; and

(4) Any change in the chemical composition of the injected CO_2 from the CO_2 composition at the time of permitting.

(b) Other significant changes to approved operational parameters contained in the original CSP permit will require compliance with Section 4.1 (b).

Section 5.0. Amalgamation of Subsurface Rights to Operate GSU

(a) Each application required under Section 4 above shall include a public hearing before SRA for the purposes of joining the necessary property ownership rights, as defined by the state or before the state regulatory agency responsible for amalgamating these rights. These hearings at the discretion of the state regulatory agencies may be combined and heard simultaneously.
(b) Each applicant for a CSP shall give notice of the filing of an application on or before the date the application is filed with SRA by mailing notice via first class mail to the following:

(1) Each operator of hydrocarbon or other mineral extraction activities, or mineral lessee of record within one-half mile external to the boundary of the proposed CSP Permit;
(2) Each owner of record of the surface property and minerals within the boundaries of the proposed CSP Permit;
(3) Each owner of record of the surface property and minerals within one-half mile external to the boundary of the proposed CSP Permit; and
(4) Any other parties as required by SRA.

(c) The above notice shall contain a legal description of the proposed CSP Permit along with the date, time, and place of the hearing before SRA and include notice of the right to file comments.
(d) In addition to mail notice of the above parties, public notice via publication shall be required. The public notice shall indicate that an application has been filed with SRA for a CSP and indicate the location of the proposed project and the date, time, and place of the hearing before SRA to determine issuance of the application. Publication shall be in a newspaper of statewide circulation and in a local newspaper in a county or parish newspaper of each county/parish in which the CSP is located. The notice shall indicate that objections may be filed within 15 days of the date of publication.
(e) Objections received by SRA shall be in writing and specify the nature of the objection.
(f) Upon review of the application submitted in accordance with Section 4 above and following the Rights Amalgamation Hearing specified in this section, authorization to commence construction of the CSP shall be issued following approval by SRA.

Section 6.0. CSP Wells

Section 6.1. CSP Well Permit Application Requirements

(a) Following receipt of authorization to commence the CSP issued by SRA in accordance with Section 4 above, the applicant shall submit applications to drill, convert, or, upon demonstration of mechanical integrity, re-enter a previously plugged and abandoned well for CO_2 storage purposes.
(b) Application for permits to drill, deepen, convert, re-enter (drill out a previously plugged well) or operate a well shall be submitted on a form prescribed by SRA and shall include at a minimum:

(1) A plat prepared by a licensed land surveyor showing the location of the proposed CO_2 injection or subsurface observation well. The plat shall be drawn to the scale of one (1) inch equals one thousand (1,000) feet, unless otherwise stipulated by SRA and shall show distances from the proposed well to the nearest GSU boundary. The plat shall show the latitude and longitude of the well in decimal degrees to five (5) significant digits. The plat shall also show the location and status of all other wells that have been drilled within one-fourth (1/4) mile, or any other distance deemed necessary by SRA, of the proposed CO_2 injection or subsurface observation well;
(2) A prognosis specifying the drilling, completion, or conversion procedures for the proposed CO_2 injection or subsurface observation well;

(3) A well bore schematic showing the name, description, and depth of the proposed reservoir and the depth of the deepest USDW; a description of the casing in the CO_2 injection or subsurface observation well, or the proposed casing program, including a full description of cement already in place or as proposed; and the proposed method of testing casing before use of the CO_2 injection well;

(4) A geophysical log, if available, through the reservoir to be penetrated by the proposed CO_2 injection well or if a CO_2 injection or subsurface observation well is to be drilled, a complete log through the reservoir from a nearby well is permissible. Such log shall be annotated to identify the estimated location of the base of the deepest USDW, showing the stratigraphic position and thickness of all confining strata above the reservoir and the stratigraphic position and thickness of the reservoir.

(c) No later than the conclusion of well drilling and completion activities, a permit application shall be submitted to operate a CO_2 injection well and shall include at a minimum:

(1) A schematic diagram of the surface injection system and its appurtenances;

(2) A final well bore diagram showing the name, description, and depths of the reservoir and the base of the deepest USDW; a diagram of the CO_2 injection well depicting the casing, cementing, perforation, tubing, and plug and packer records associated with the construction of the CO_2 injection well;

(3) A complete dual induction or equivalent log through the reservoir of the CO_2 injection well. Such log for wells drilled for CO_2 injection operations shall be run prior to the setting of casing through the CO_2 storage reservoir. Logs shall be annotated to identify the estimated location of the base of the deepest USDW, showing the stratigraphic position and thickness of all confining strata above the reservoir and the stratigraphic position and thickness of the reservoir unless previously submitted. When approved in advance by SRA, this information can be demonstrated with a dual induction or equivalent log run in a nearby well or by such other method acceptable to SRA;

(4) An affidavit specifying the chemical constituents of the injection stream other than CO_2 and their relative proportions;

(5) Proof that the long string of casing of the CO_2 injection well is cemented adequately so that the CO_2 is confined to the GSU. Such proof shall be provided in the form of a cement bond log or the results of a fluid movement study or such other method specified by SRA; and

(6) The results of a mechanical-integrity test, if applicable to well type, of the casing in accordance with the pressure test requirements, of this section, if a test was run within one calendar year preceding the request for issuance of a conversion permit for a previously drilled well.

Section 6.2. Permit Issuance

(a) Upon review and approval of the application to drill, deepen, convert, re-enter, (drill out a previously plugged well) or operate a CO_2 injection well, submitted in accordance with Section 6.1, SRA shall issue permits to drill and operate.

(b) A permit shall expire twelve (12) months from the date of issuance if the permitted well has not been drilled or converted.

Section 6.3. CSP Well Operational Standards

(a) Surface casing in all newly drilled CO_2 injection and subsurface observation wells drilled below the USDW shall be set 100 feet below the lowest USDW and cemented to the surface or other protective measures as deemed appropriate by SRA.

(b) The long-string casing in all CO_2 injection and subsurface observation wells shall be cemented with a sufficient volume of cement to fill the annular space to a point 500 feet above the top of the storage reservoir.
(c) Any liner set in the well bore shall be cemented with a sufficient volume of cement to fill the annular space to the surface.
(d) All cements used in the cementing of casings in CO_2 injection and subsurface observation wells shall be of sufficient quality to maintain well integrity in the CO_2 injection environment.
(e) All casings shall meet the standards specified in either of the following documents, which are hereby adopted by reference:

(1) "The most recent American Petroleum Institute (API) Bulletin on performance properties of casing, tubing, and drill pipe; or
(2) "Specification for casing and tubing (U.S. customary units)," API specification 5CT, as published by the API in October 1998; or
(3) Other casing as approved by SRA.

(f) All casings used in new wells shall be new casing or reconditioned casing of equivalent quality that has been pressure-tested in accordance with the requirements of paragraph (e). For new casings, the pressure test conducted at the manufacturing mill or fabrication plant may be used to fulfill the requirements of paragraph (e).
(g) The location and amount of cement behind casings shall be verified by a cement bond log, cement evaluation log, or any other evaluation method approved by SRA.
(h) All CO_2 injection wells shall be completed with and injection shall be through tubing and packer.
(i) All tubing strings shall meet the standards contained in paragraph (e) of this regulation. All tubing shall be new tubing or reconditioned tubing of equivalent quality that has been pressure-tested. For new tubing, the pressure test conducted at the manufacturing mill or fabrication plant may be used to fulfill this requirement.
(j) All wellhead components, including the casing head and tubing head, valves, and fittings, shall be made of steel having operating pressure ratings sufficient to exceed the maximum injection pressures computed at the wellhead and to withstand the corrosive nature of CO_2. Each flow line connected to the wellhead shall be equipped with a manually operated positive shutoff valve located on or near the wellhead.
(k) All packers, packer elements, or similar equipment critical to the containment of CO_2 shall be of a quality to withstand exposure to CO_2.
(l) An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. Gauges shall be calibrated as required by SRA and evidence of such calibration shall be available to SRA upon request.
(m) All newly drilled wells shall establish internal and external mechanical integrity as specified by SRA and demonstrate continued mechanical integrity through periodic testing as determined by SRA. All other existing wells to be used as CO_2 injection wells will demonstrate mechanical integrity as specified by SRA prior to use for CO_2 injection and be tested on an ongoing basis as determined by SRA using these methods:

(1) Pressure tests. CO_2 injection wells, equipped with tubing and packer as required, shall be pressure tested as required by SRA. A testing plan shall be submitted to SRA for prior approval. At a minimum, the pressure shall be applied to the tubing casing annulus at the surface for a period of 30 minutes and shall have no decrease in pressure greater than 10 percent of the required minimum test pressure. The packer shall be set at a depth at which the packer will be opposite a cemented interval of the long string casing and shall be set no more than 50 feet above the uppermost perforation or open hole for the CO_2 storage reservoir; and

(2) SRA may require additional testing such as bottom hole temperature and pressure measurements, tracer survey, temperature survey, gamma ray log, neutron log, noise log, casing inspection log, or a combination of two or more of these surveys and logs, to demonstrate mechanical integrity.

(n) Supervision of mechanical integrity testing. SRA may witness all mechanical integrity tests conducted by each CSP operator for regulatory purposes.

(o) If a CO_2 injection well fails to demonstrate mechanical integrity by an approved method, the operator of the well shall immediately shut in the well, report the failure to SRA, and commence isolation and repair of the leak. The operator shall, within 90 days or as otherwise directed by SRA, perform one of the following:

(1) Repair and re-test the well to demonstrate mechanical integrity;
(2) Plug the well in accordance with state requirements; or
(3) Comply with alternative plan as approved by SRA.

(p) All CO_2 injection wells shall be equipped with down-hole safety shutoff valves.

(q) Additional requirements may be required by SRA to address specific circumstances and types of projects not specified in these rules.

Section 6.4. Amendment to CSP Well Permits

(a) An amendment to the CSP Well Permit for: (1) a change in injection formation, and/or (2) a modification of maximum allowable injection rate and pressure, shall comply with the provisions of Section 6.1 (c)(5) and (6), 6.3 (b), (g), (h), (i), (l) and (m) above.

(b) Modification of well construction shall comply with the provisions of Section 6.1 (b)(3) and 6.3 (m).

Section 7.0. CSP Operational Standards

Section 7.1. Safety Plans

Each operator of a CSP shall implement a SRA-approved CF public safety and emergency response plan and the worker safety plan proposed in Section 4. This plan shall include emergency response and security procedures. The plans, including revision of the list of contractors and equipment vendors, shall be updated as necessary or as SRA requires. Copies of the plans shall be available at the CF and at the nearest operational office of the holder of the CSP Permit.

Section 7.2. Leak Detection and Reporting

(a) Leak detectors or other approved leak detection methodologies shall be placed at the wellhead of all CO_2 injection and subsurface observation wells. Leak detectors shall be integrated, where applicable, with automated warning systems and shall be inspected and tested on a semi-annual basis and if defective, shall be repaired or replaced within 10 days. Each repaired or replaced detector shall be re-tested if required by SRA. An extension of time for repair or replacement of a leak detector may be granted upon a showing of good cause by the operator of the CSP. A record of each inspection, which shall include the inspection results, shall be maintained by the operator for at least five years and shall be made available to the state oil and natural gas regulatory agency upon request.

(b) The operator of a CSP shall immediately report to SRA any leaks detected at the surface facility and associated well equipment specified in (a) above.

(c) The operator of a CSP shall immediately report to SRA any pressure changes or other monitoring data from subsurface observation wells that indicate the presence of leaks in the GSU indicating the lack of confinement within the reservoir of the CO_2.
(d) The operator of a CSP shall immediately report to SRA any other indication of lack of containment of CO_2 to the reservoir not associated with wells and surface equipment.

Section 7.3. Other General Requirements

(a) Each operator shall be required to conduct a corrosion monitoring and prevention program approved by SRA.
(b) Identification signs shall be placed at each facility in a centralized location and at each well site and show the name of the operator, the facility name, and the emergency response number to contact the operator.

Section 8.0. Reporting Requirements

(a) The volume of CO_2 injected into and/or withdrawn since the last reporting, the average injection rate, average composition of the CO_2 stream, wellhead and down hole temperature and pressure data and/or other pertinent operational parameters as required by SRA shall be reported quarterly or as required by SRA.
(b) These quarterly reports shall be compiled and summarized annually to provide updated projections of the response and storage capacity of the GSU. The projections shall be based on actual GSU operational experience, including all new geologic data and information. All anomalies in predicted behavior as indicated in the most current permit conditions shall be explained and, if necessary, the permit conditions amended in accordance with Section 4.1.

Section 9.0. CSP Closure

(a) Prior to the conclusion of the operational period, the time period to be determined by SRA, the CSP permit holder shall provide an assessment of the operations conducted during the operational period, including but not limited to the volumes injected, extracted, any and all chemical analyses conducted, summary of all monitoring efforts, etc. The report shall also document the position and characteristics of the areal extent of the CO_2 and a prediction of the extent and movement of the CO_2 volume anticipated during the CSP closure period.
(b) The permittee shall submit a monitoring plan for the CSP closure period for approval by SRA, including but not limited to a review and final approval of which wells will be plugged and which wells will remain unplugged to be used as CSP closure and post closure period subsurface observation wells.
(c) Following well plugging, all associated surface equipment shall be removed and the well site returned to its original land use to the extent possible.
(d) The well casing shall be cut off at a depth of 5 feet below the surface and a steel plate welded on top identifying well name and that it was used for CO_2 injection.
(e) SRA shall develop in conjunction with the permittee a continuing monitoring plan for the CSP post closure period including but not limited to a review and final approval of which wells shall be plugged. SRA shall have full control of and responsibility for the remaining unplugged wells to be used by SRA as CSP post closure period subsurface observation wells or for other purposes as deemed necessary by SRA.
(f) Upon CSP closure, all wells so designated by SRA shall be properly plugged and abandoned, all CF equipment and facilities shall be removed, and the CSP site reclaimed in accordance with SRA requirements.

(g) All subsurface observation and groundwater monitoring wells as approved in the CSP closure period monitoring plan shall remain in place for continued monitoring during CSP closure period.
(h) Upon termination of the CSP closure period, the permittee shall provide a final assessment of the subsurface position and the characteristics of the CO_2 volume within the GSU including the future movement and position of the CO_2 volume within the GSU.
(i) Wells other than those deemed as subsurface observation wells per paragraph (e) above, shall be plugged by the permittee in accordance with paragraph (c) above.
(j) At the conclusion of the CSP closure period, the CSP performance bond maintained by the CSP operator shall be released, and continued monitoring of the site, remediation of any well leakage, including wells previously plugged and abandoned by the CSP operator, shall become the responsibility of designated state or federal agency programs and the CSP operator and generator of the CO_2 shall be released from further SRA regulatory liability relating to the CF.

Appendix III: Bibliography of Cases and References on Property Rights Issues Related to Underground Space Used for Geologic Storage of Carbon Dioxide

Cases

Cent. Ky. Natural Gas Co. v. Smallwood, 252 S.W.2d 866, 868 (Ky. Ct. App. 1952).

Chance v. BP Chemicals, Inc., 670 N.E.2d 985 (Ohio 1996).

Dep't of Transp. v. Goike, 560 N.W.2d 365, 366 (Mich. Ct. App. 1996).

Ellis v. Ark. La. Gas Co., 609 F.2d 436, 439 (10th Cir. 1979).

Emeny v. United States, 412 F.2d 1319 (Ct. Cl. 1969).

Humble Oil & Refining Co. v. West, 508 S.W.2d 812 (Tex. 1974).

Mapco, Inc. v. Carter, 808 S.W.2d 262 (Tex. App.—Beaumont 1991), *rev'd in part*, 817 S.W.2d 686 (Tex. 1991).

Mission Res., Inc. v. Garza Energy Trust, 166 S.W.3d 301, 310 (Tex. App.—Corpus Christi 2005, review granted.

Mongrue v. Monsanto Co., 249 F.3d 422, 433 n. 17 (5th Cir. 2001).

R.R. Comm'n of Tex. v. Manziel, 361 S.W.2d 560, 568 (Tex. 1962)

Tate v. United Fuel Gas Co., 71 S.E.2d 65, 72 (W. Va. 1952).

Tex. Am. Energy Corp. v. Citizens Fid. Bank & Trust Co., 736 S.W.2d 25, 28 (Ky. 1987).

United States v. 43.42 Acres of Land, 520 F.Supp. 1042, 1045 (W.D. La. 1981).

Other Authorities

Carbon Dioxide Sequestration: Interim Report on Identified Statutory & Regulatory Issues, New Mexico Energy, Minerals, Natural Resources Dep't, Oil Conservation Division, pp. 12-13 (June 27, 2007).

Elizabeth J. Wilson & Mark A. de Figueirdo, Geologic Carbon Dioxide Sequestration: An Analysis of Subsurface Property Law, 36 ELR 10114, 21 (2006).

Holland, "Underground Storage of Natural Gas: A Legal Overview," 3 Eastern Min. L. Inst. 19 – 1 at 19 – 13 (1982).

Treatise

Williams and Meyers, Oil and Gas Law Vol. 1, §222 (Matthew Bender, 2006).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 16 2009

OFFICE OF
WATER

The Honorable John Dingell
Chairman
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Dingell:

Thank you for your letter of December 2, 2008, providing questions on the Environmental Protection Agency's (EPA) June 24, 2008, testimony regarding the Agency's important work on capture and storage of carbon dioxide and the Agency's July 25, 2008, regulatory proposal under the Safe Drinking Water Act (SDWA). EPA is committed to continuing its efforts to help the Nation realize the significant potential of carbon dioxide capture and geologic sequestration, while protecting our vital underground water resources. Responses to your questions are provided as an enclosure to this letter.

Again, thank you for the opportunity to describe EPA's important work on geologic sequestration. If you have further questions, please contact me or your staff may call Greg Spraul, in EPA's Office of Congressional and Intergovernmental Relations, at (202) 564-0255.

Sincerely,

BH Grumbles

Benjamin H. Grumbles
Assistant Administrator

Enclosure

Thank you for your service

House Energy and Commerce Committee
Subcommittee on Environment and Hazardous Materials
June 24, 2008 Hearing on *Carbon Sequestration: Risks, Opportunities, and Protection*
Questions for the Record

The Honorable Gene Green

1. **Is there a gap in the Environmental Protection Agency (EPA) authority to regulate releases of carbon dioxide coming up from an injection well or sequestration project back to the atmosphere?**

The requirements proposed in the preamble of the July 2008 proposed Underground Injection Control (UIC) program geologic sequestration (GS) rule, are designed to protect Underground Sources of Drinking Water (USDW) by isolating the injected CO_2 stream from the atmosphere. The SDWA provides EPA with the authority to develop regulations to protect USDWs.

While the primary purpose of the proposed GS regulation is to protect USDWs, EPA recognizes that injection activities could pose risks that are unrelated to the protection of USDWs including risks to the atmosphere, surface water, human health, ecosystems, and the physical environment. Under the SDWA, EPA does not have the authority to regulate releases to the atmosphere or to verify greenhouse gas (GHG) emissions reductions; however, the measures taken to prevent migration of CO_2 into USDWs may indirectly address the risk of CO_2 migration back to the atmosphere.

At this time EPA is still evaluating any additional authority that the Agency may have under other statutes which it administers.

2. **Would a permit written under EPA's proposed regulations, *Federal Requirements Under the Underground Injection Control Program for Carbon Dioxide Geologic Sequestration Wells*, 73 FR 43491 (July 25, 2008), be able to mandate provisions to prevent such an atmospheric release of carbon dioxide from a sequestration project?**

EPA is proposing regulations that would require permits to be written in a manner that ensures that CO2 or displaced fluids do not endanger USDWs. This will reduce the potential for movement from the intended injection zone thereby reducing the risk of CO2 release to the atmosphere. This is accomplished through careful siting, construction, operation, testing and monitoring, plugging, and post-injection site care and closure requirements to assure the proper management of CO2 injection and storage.

While the UIC program is not specifically designed to prevent atmospheric releases of carbon dioxide the proposed requirements will minimize the potential for these releases and, as mentioned above, EPA is evaluating any additional authority that the Agency may have under other statutes which it administers.

3. **Does the imminent and substantial endangerment authority of Section 1431 of the Safe Drinking Water Act which reads "may present an imminent and substantial endangerment to the health of persons" give EPA authority to seek injunctive action to prevent contamination of underground sources of drinking water in the case where no one is actually drinking water from the aquifer?**

Yes, Section 1431 gives EPA broad authority to seek administrative, civil and criminal penalties in the event that injection activities endanger the health of persons and EPA believes that this authority extends to aquifers that may provide a source of drinking water in the future.

4. **Does EPA's authority under the Safe Drinking Water Act allow EPA to place permit conditions on an owner/operator of a sequestration project that are designed to prevent damage to ecosystems?**

EPA is proposing regulations for GS wells that would require permits to be written in a manner that ensures that CO_2 or displaced fluids do not endanger USDWs. This will reduce the potential for fluid movement from the injection zone, thereby indirectly protecting ecosystems.

<u>The Honorable John Shadegg</u>

1. **Is it clear to you that the Environmental Protection Agency (EPA) has authority to create a sixth class of wells under the underground injection control program? Do you have clear statutory authority to impose the financial responsibility requirements that you contemplate in your proposed rulemaking?**

Yes, EPA believes it has authority under the SDWA to create new well classes and to impose financial responsibility requirements that protect USDWs from injection activities during construction, operation and post-closure periods. EPA's authority to regulate GS wells was further clarified under the Energy Independence and Security Act of 2007, which stated that all regulations must be consistent with the requirements of the SDWA.

2. **You mention the program authority to require air monitoring at the surface. Is this done entirely to determine whether there has been leakage to an underground source of drinking water or would the data also be used to measure greenhouse gas concentrations in the atmosphere?**

The primary purpose of surface air monitoring would be to indicate movement of CO_2 outside of the intended storage reservoir which could endanger USDWs. The utility of this data for purposes beyond compliance with a UIC permit will be a function of the site-specific monitoring approaches and techniques.

3. **The EPA's proposed rule issued on July 15, 2008 does not contain any provisions regarding the liability associated with CO_2 sequestering. Without a liability framework in place it will be exceptionally difficult to make a decision on whether to pursue a plan**

of carbon sequestration. Does the EPA intend to address liability under CERCLA or RCRA?

Under the proposal, EPA is requiring owner/operators of GS projects to maintain financial responsibility for site management, closure, and monitoring until the potential risks are extremely low. While liability remains with the owner/operator even after site closure, EPA believes that with proper siting, construction, operation, and monitoring, the risks from a GS project will decrease over time after injection ceases. EPA is seeking comment through the proposed rule on the appropriateness of proposed financial responsibility provisions, liability, and other existing authorities as they relate to long term geologic storage of CO_2.

EPA is also working with other federal partners to assess implications of various statutes on the development of GS. We have begun an analysis of how various EPA statutes may apply to the proposed regulation of GS and expect to complete the analysis this spring. We hope that this analysis, together with input we receive through the public comment process related to this rulemaking, will provide valuable insight on these important issues.

4. **You mention sub-seabed storage of CO_2. Please give us your prospect today for that option. Do you think it will ever be viable? What are its advantages and disadvantages?**

Sub-seabed storage of CO_2 is technically viable, as demonstrated by the commercial project Sleipner West (Norway). However, EPA is not aware of any projects targeting sub-seabed formations for geologic sequestration of CO_2 in the U.S.

The Marine Protection Research and Sanctuaries Act (MPRSA) requires a permit to transport any material for purpose of dumping it into ocean waters. EPA's longstanding interpretation is the MPRSA covers sub-seabed disposal. Proposed amendments to the MPRSA to ratify and implement the London Protocol would explicitly cover dumping and storage of material in the sub-seabed to reflect a similar provision in the Protocol. Among the proposed changes is a provision to allow for and regulate carbon sequestration in sub-seabed geological formations under the MPRSA. Under the SDWA, any sub-seabed injection of carbon dioxide streams in geological formations beneath ocean waters within a State's territorial waters, generally three miles from shore with the exception of Florida and Texas, also must comply with any applicable requirements under EPA's UIC program regarding the design, operation, and closure of underground injection wells.

ROBERT C. BURRUSS, RESPONSE TO QUESTION FROM MR. SHADEGG

1.Dr. Burruss, in your testimony you outline a very rigorous geologic storage assessment framework which takes into account not only the unique geology of depleted oil and gas fields, saline formations, and unmineable coal beds and their respective, unique sealing formations, but also the assessment of ground-water resources. All of this data will be assigned a risk factor. Once all of the numbers are crunched and all of the scientific data checked and double-checked, how safe can we expect carbon sequestration to be?

Geologic carbon sequestration is known to be very safe in certain environments and under certain conditions. Over the last 30 years in the United States, large volumes of carbon dioxide have been routinely injected into oil reservoirs to enhance production of oil. Although most of the injected CO_2 is co-produced with the oil, separated and re-injected for additional oil recovery, some CO_2 remains in the reservoir and is therefore sequestered. We know that geological formations, such as oil and gas reservoirs, that have an overlying seal formation (caprock) are safe for carbon sequestration because they have held oil and gas for millions of years. It is true, though, that during the lifetime of oil or gas reservoirs, they have been penetrated by well bores that could be sources of leakage. The drilling history of individual sequestration sites must be reviewed carefully to ensure that all previously drilled wells are properly plugged to prevent leakage of CO_2 or brine to the surface or to shallow drinking water supplies. Other potential storage sites such as deep saline formations (saline aquifers) are much less characterized than depleted oil and gas reservoirs. Such sites will require extensive characterization prior to deployment of geologic sequestration to ensure that the CO_2 is fully contained within the formation.

In part, discussions of the safety of geologic sequestration of CO_2 depend on what is meant by "safe," whether the process is safe in terms of leakage to the surface, safe from contamination of drinking water, or in terms of any of the technologies for transporting and pumping high pressure carbon dioxide into the ground. The technology exists to safely pressurize, transport, and inject carbon dioxide into the ground because we have been doing this as part of enhanced oil recovery for over 30 years. However, the volumes of CO_2 that must be injected for geologic sequestration to be an effective technology for mitigation of climate change are large, and there are fundamental questions of science that must be addressed before the safety of geologic sequestration can be fully understood. For example, we must understand the extent to which fluids and pressure variations are dispersed throughout a saline formation over decades as large volumes of CO_2 are injected.

Department of Energy
Washington, DC 20585

January 15, 2009

The Honorable John D. Dingell
Chairman
Subcommittee on Environment and Hazardous Materials
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On July 24, 2008, Scott Klara, Director, Strategic Center for Coal, National Energy Technology Laboratory, testified regarding "Carbon Sequestration: Risks, Opportunities, and Protection of Drinking Water."

Enclosed are the answers to eight questions submitted by Representative Shadegg to complete the hearing record.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

Lisa E. Epifani
Assistant Secretary
Congressional and Intergovernmental Affairs

Enclosures

QUESTION FROM REPRESENTATIVE SHADEGG

Q1. What is the U.S. Department of Energy (DOE) doing to understand the risks associated with CO_2 injection?

A1. DOE's Carbon Sequestration Program has a range of efforts that will improve our understanding of risks associated with CO_2 injection. Over 30 field projects are being implemented to research and investigate any impacts resulting from CO_2 injection (particularly as it relates to groundwater). In addition, several projects are investigating key issues in seal integrity, including issues related to wellbore-cement integrity and faults and fractures.

Through NETL's Office of Research and Development, National Laboratories, and the Regional Carbon Sequestration Partnerships, DOE supports applied research projects to develop risk assessment protocols which can then be applied to field projects. The Department is also working with the U.S. EPA to transfer the lessons learned from DOE-supported work. DOE and EPA co-fund a project on sequestration risks associated with geochemical changes and regional pressure impacts of commercial-scale injection operations. DOE and NETL have also been coordinating two helpful efforts. The first is the development of a "National Risk Assessment Network" between several National Laboratories. The second is a coordination of discussions to leverage our knowledge base of CO_2 storage risks with several other organizations, including EPA, the Carbon Sequestration Leadership Forum, and the International Energy Agency's Greenhouse Gas Programme.

QUESTION REPRESENTATIVE SHADEGG

Q2. Through the leadership and support from DOE, the Regional Carbon Sequestration Partnerships are implementing over 30 field projects which you highlighted in your testimony. How will the lessons learned from these field projects help prove and refine the capacity estimates which DOE has presented and aid the United States Geological Survey (USGS) in their effort?

A2. Through the Regional Carbon Sequestration Partnerships, DOE is implementing field projects in saline formations, depleted oil fields, and coal seams to validate that the assumptions used to determine the storage estimates in different reservoirs are reasonable and accurate. Monitoring data and simulation results from the field projects will help better define the geologic formation's "efficiency factors" which are used in the volumetric capacity assessment completed by DOE and the Partnerships in coordination with USGS. These efficiency factors will be adjusted in future storage estimates if the field test data demonstrate that changes are necessary for specific assumptions (like reservoir architecture and buoyancy). The field projects are testing several different geologic formation types. These field projects will provide better insight into the effects of reservoir pressure on the capacity of various formations. These results will be used by both DOE and USGS to improve the accuracy of storage estimates throughout the United States and Canada.

QUESTION FROM REPRESENTATIVE SHADEGG

Q3. The Regional Partnerships seem to be a key to developing the National Atlas. Do the partnerships maintain their own regional atlases and are these Regional Atlases available to local organizations?

A3. Yes, each Regional Partnership maintains a detailed database on CO_2 sources and storage locations in their respective region. This core data from each Regional Partnership feeds the National Carbon Database (NATCARB) which is then used to generate the results for each version of the National Atlas. Information is available to the public, and significant effort is spent on outreach to ensure maximum distribution of information. In fact, DOE/NETL and the Regional Partnerships field hundreds of requests from industry, governments, and other organizations every year on specific requests for data and maps of specific regional locations.

QUESTION FROM REPRESENTATIVE SHADEGG

Q4. It is recognized that the development of the Atlas is a significant accomplishment and the individuals working at DOE, the Regional Carbon Sequestration Partnerships, and NatCarb should all be commended for their work to create it. It is recognized that this effort will continue through DOE in collaboration with EPA and USGS. Given the state of the current knowledge surrounding CO2 sequestration capacity what should the priority be to refine these estimates?

A4. Thank you for the recognition of the Atlas. It represents the combined effort of many individuals and organizations. The estimates in the Atlas are considered storage resource estimates and, in some cases, are based on limited data sets, particularly for saline formations. The resource estimates are conservative but should continue to be refined to decrease the degree of uncertainty by supporting: (1) additional research efforts to study the effects of CO_2 storage in different geologic settings; (2) take advantage of existing oil and gas drilling in basins throughout the United States to better characterize known and undiscovered saline formations; (3) additional field projects in different geologic settings to validate the capacity and injectivity estimates to begin adding economic constraints to the estimates; (4) research on the effects of developing an entire basin and its effects on injectivity and capacity estimates (as it relates to "pressure management" issues); and (5) efforts to characterize the offshore deep geologic formations for storage capacity.

QUESTION FROM REPRESENTATIVE SHADEGG

Q5. There seems to be significant storage capacity in the United States to store hundreds of years of CO_2 emissions in the future. Do you expect that additional storage capacity to be added to the Atlas as the Regional Partnerships collect more information on the geology of their regions that is conducive to storage?

A5. Yes, DOE would expect additional storage resources to be identified. DOE released the second version of the National Atlas in November 2008, which has shown moderate increases in storage capacity in oil fields and coal seams as additional resources have been characterized over the past two years. The most significant increase in storage capacity was shown to be in sub-seabed geologic reservoirs off the Gulf and Atlantic coasts. These deep geologic formations under the ocean floor increased the storage capacity available in saline formations to over 12,000 billion tons of storage capacity, four times more than the previous estimates. These storage estimates would require field validation at each speculative project site before undertaking a major CCS field project.

QUESTION FROM REPRESENTATIVE SHADEGG

Q6. In terms of funding and other resources, how much has the DOE and the Regional Partnerships invested in the development of the National Atlas?

A6. DOE has invested approximately $25 million in the development of both versions of the National Atlas, of which $17 million was spent through the Regional Partnerships. In addition, the Regional Partnerships have spent $7 million of non-Federal money on the National Atlas.

QUESTION FROM REPRESENTATIVE SHADEGG

Q7. Are the organizations involved in the development of the National Atlas the same type of organizations which would be involved in the effort proposed by the USGS?

A7. Yes, the USGS would likely work with nearly all of the same organizations that DOE has supported over the past 6 years.

QUESTION FROM REPRESENTATIVE SHADEGG

Q8. Have external agencies reviewed the methodology used to develop the capacity estimates in the National Atlas?

A8. Yes, the American Society of Mechanical Engineers (ASME) convened a peer review committee of physical scientists to review the capacity methodology prior to the development of the estimates for the second version of the Atlas. This was above and beyond the rigorous review that is performed by DOE/NETL and the Capacity and Fairways Subgroup of the Geologic Working Group within the Regional Partnerships. These working groups included representatives from state geologic surveys, academia, and national laboratories. The USGS has also agreed to be involved in reviewing the methodology used to develop the capacity estimates.

LAWRENCE E. BENGAL, RESPONSE TO QUESTIONS FROM MR. SHADEGG

1.Should we rush forward with adopting a carbon cap-and-trade scheme and begin sequestration on a massive scale before all the states and the Environmental Protection Agency (EPA) have a chance to complete the regulatory framework governing sequestration?

Mr. Bengal: It is my view that until legislation is passed that either sets a cap on the amount of carbon emitted into the atmosphere (cap-and-trade legislation) or imposes a tax on carbon that's emitted into the atmosphere (carbon tax), that there will be little impetus for the robust development of carbon sequestration projects in the United States. Should there be interest on the part of developers in moving forward with one or more large projects before the passage of any such legislation, there would be nothing to prevent that from occurring if a willing state used either existing regulatory frameworks (state and EPA) or frameworks such as many states are developing. Wyoming, Kansas and Washington are close to having complete frameworks in place and legislatures in North Dakota, Montana, New Mexico, Texas, West Virginia, California, Michigan and Oklahoma are expected to take up legislation in 2009. Legislation limiting the emission of carbon into the atmosphere (either cap-and-trade legislation or a carbon tax) will only help facilitate the implementation of storage projects and it should not be necessary to postpone adoption of such measures awaiting the completion of regulatory development by the states or the EPA. Cap and trade or carbon tax legislation will not mandate CO_2 storage, which is only one method to reduce emissions, on the contrary having a known emission standard in-place will only help industry move forward to address the unresolved issues. Issues that are not yet addressed, such as long term liability, could be dealt with by states using existing state authorities providing there was a willingness on the part of the state to do so.

2.You say that 7 states have either adopted or are in the process of adopting regulations governing carbon geologic storage. Have these states addressed the liability issues associated with CO_2 storage? Have they adopted the state trust fund mechanism you describe?

Mr. Bengal: To my knowledge none of the states that have adopted the state trust fund mechanism as proposed and set forth in the IOGCC model. We understand, however, that some states could very shortly enact legislation providing for such a state trust fund mechanism. In the meantime, the states that have adopted legislation have taken different positions on the liability issue to the extent they have even addressed the issue.

3.Do you think the Post-Closure trust fund mechanism is adequate to address all the liability issues associated with sequestration? Especially for early projects, who may be storing CO_2 at previously untested volumes, do there need to be additional liability protections to enable the private sector to more forward on projects?

Mr. Bengal: There are two primary types of liability that will need to be addressed One of these is concerned with the operational or caretaker functions of the project in its post-closure phase. The second is concerned with claims for personal injury or property damage that might result from leakage of stored CO_2 in the post-closure phase.

The state trust fund was designed to address the first of these two types of liability, pertaining to the operational or caretaker functions of the project which deal with the long term monitoring programs, verification methods and remediation of any mechanical or geologic leaks which could impact public health and safety. The state trust fund mechanism was not designed to address personal or property damage claims arising during the post-closure phase of the project. This type of liability would have to be addressed either legislatively or through the purchase of commercial insurance, potentially by the trust fund.

Uncertainty about liability is a stumbling block for early projects. Any protections or clarifications that could be provided to industry by government to reduce their uncertainty about liability exposure will greatly enhance the development of early projects.

4.I find your description of CO_2 storage as a resource management problem rather than a waste disposal one fascinating. Could you discuss this in more detail? Is it because of the market potential of CO_2 in EOR and other uses?

Mr. Bengal: The Task Force concluded that the commodity vs. pollutant or waste debate was unproductive and decided that a "resource management" approach made much more sense. Waste regulatory frameworks deal with point source emissions and the local area impacts of those emissions. This type of regulatory framework

would only complicate the management of CO_2 emissions. CO_2 released into the atmosphere as a consequence of the combustion of fossil fuels is of concern primarily for its global impact (climate change) and not its local impact. Not every source of CO_2 emission will need to be regulated in order to have a significant impact on overall emission reduction.

A key conclusion reached by the Task Force was that nothing is gained by viewing CO_2 as a pollutant or waste. In fact it was reasoned that such a designation only exacerbated the regulatory complexity of CO_2 storage which unlike wastes include: ownership and management of the pore space, maximization of storage capacity, potential use of the CO_2 for enhanced oil recovery (EOR), long term liability, issues of environmental protection, and issues of pipeline access. CO_2 as a resource rests in part on viewing CO_2 as a byproduct of the public's demand for energy, a resource, produced through combustion of fossil fuels, another resource. In addition, given CO_2 is a consequence of the public's use of a resource to produce energy resources it is logical that yet another public resource, underground storage reservoirs, be used to store that byproduct. Viewed in this context regulating CO_2 under a resource management framework allows the state to manage a variety of resources in a comprehensive manner for the benefit of its citizens.

Put another way, to view the regulation of storage of CO_2 under a waste disposal framework (as a pollutant or waste) sidesteps the public role in both the creation of CO_2 and the mitigation of its release into the atmosphere and places the burden solely on industry to rid itself of ″waste″ from which an ″innocent″ public must be ″protected″. Such an approach lacking citizen buy-in with respect to the public's responsibility for the problem as well as the solution could well doom geological storage to failure and diminish significantly the potential of geologic carbon storage to meaningfully mitigate the impact of CO_2 emissions on the global climate.

A resource management framework, as proposed by the Task Force, allows for the integration of these issues into a unified regulatory framework that facilitates a ″public sector-private sector partnership″ to address the long-term liability, given that the release of CO_2 into the atmosphere is at least partially a societal problem and that the mitigation of that release is likewise at least partially a societal responsibility. In this way the state is able to use and manage underground storage space as a valuable state asset to the benefit of its citizens.

In response to the last part of the question, although CO_2 used in EOR projects is a commodity and was an important component in determining to propose a resource management framework, it was not the sole driver. There were many other factors and considerations, as enumerated above.

DON BROUSSARD, RESPONSE TO QUESTION FROM MR. SHADEGG

1.Mr. Broussard, you rightly express concern about the safety and cleanliness of our drinking water. I certainly would not advise any legislation or authorize any programs that would leave a great risk of polluting our underground sources of drinking water. What I gather from your testimony, however, is that you advise and accept the idea of gradual, measured studies and carbon sequestration pilot project that would monitor the safety of these underground drinking water sources?

While the UIC program has a long history, the injection of CO_2 into the ground is a process that is not well understood. This substance is different from substances currently regulated under the UIC, and the behavior of the compound under severe pressures and temperatures is not well known. AWWA believes that gradual, measured studies and pilot projects must be conducted before carbon sequestration is embraced as a feasible technology to combat climate change. The Department of Energy's Phase III Regional Carbon Sequestration Partnership projects should provide some of this information, and we look forward to reviewing the data when it becomes available. However, the results of these large-scale projects are several years off and there is currently limited research available, with the exception of the Sleipner project on what happens in the subsurface between groundwater, carbon dioxide and the surrounding rock strata in large-scale geologic sequestration activities. Also, AWWA strongly recommends that EPA and DOE perform both modeling (theoretical) and observational research to better understand the carbon sequestration process and the effects of CO_2 injection on saline aquifers and the subsurface geology.

AWWA believes that the results of the DOE research are crucial to the development of a comprehensive regulation that protects water resources from the potential unintended consequences of geologic carbon sequestration. In particular, AWWA believes that research on the potential pathways for contamination of USDWs has not

yet been completed. As a result, we are concerned that the appropriate subsurface monitoring methods and technologies have not been adequately identified or developed. AWWA believes that more detailed research is needed to identify the specific requirements for subsurface monitoring that can protect USDWs from contamination due to geologic carbon sequestration.

It is important to note that unintended consequences from geologic sequestration might not manifest themselves for decades or even centuries. This is another reason to move cautiously forward and provide for extensive review of the pilot projects before proceeding with careful site selection and robust mitigation plans/resources for commercial scale projects. Having observed significant unintended consequences recently with both MTBE and biofuels, we believe that more information needs to be obtained regarding how CO_2 performs in large-scale projects. We also need the chance to observe these pilot projects for any unintended consequences before we move ahead with commercial deployment of this technology.

While we recognize that drinking water utilities will be affected by climate change, this does not mean that we should rush to embrace a technology before results from large-scale pilot projects are available. Taking careful, deliberate steps in the development of CCS technology will ensure we have a very clear understanding of the potential impacts.

The proposed scale of carbon sequestration is unprecedented compared with traditional enhanced oil and gas recovery, increasing the potential for unintended consequences. As such, AWWA recommends that DOE and EPA include the drinking water utilities that are directly impacted by the carbon sequestration pilot projects as stakeholders. Potentially impacted utilities must be involved in the development of appropriate aquifer monitoring programs for the pilot programs to appropriately ensure that the water resources are not adversely affected. This will allow the utilities to gain first hand experience regarding how the sequestration process will be implemented.

In summary, AWWA does believe that much more research and large-scale pilot projects - with potentially effected drinking water systems as partners - is required before geosequestration of carbon dioxide becomes a widely used technology.

A. Scott Anderson, Response to Questions from Mr. Shadegg

1.You say that the market is ″far more effective and efficient . than any suite of government mandates or subsidies.″ Isn't a cap-and-trade scheme itself just a massive government mandate?

Response:I should have said that markets are far more efficient at allocating resources than government mandates or subsidies. Certainly the ″cap″ portion of cap-and-trade counts as a mandate. Cap-and-trade considered as a whole, however, goes well beyond setting a cap on greenhouse gas emissions, and does so by incorporating market forces. By providing for a market in emissions allowances, a cap-and-trade system will enable the private sector to determine the most efficient pattern of emission reductions, thus reducing overall compliance costs compared to an approach that simply mandated all sources to reduce emissions by a prescribed amount.

2.You say that you're unconvinced that liability relief is necessary. You cite models based on current operations, such as enhanced oil recovery or hazardous waste injection. Doesn't the unique nature of CO_2 - it's viscosity, buoyancy and corrosivity - make its storage an inherently different case?

Response:No. Enhanced oil recovery operations annually have been injecting tens of millions of tons of CO_2 since the 1970s, and the carbonic acid that forms when CO_2 mixes with water is not nearly as corrosive as some of the substances that are injected in hazardous waste injection wells. Neither is CO_2 explosive -- as is the case with natural gas that storage facility operators store (usually quite safely) in geologic formations near or beneath populated areas. What is unique about the geologic sequestration of CO_2, compared to these other underground injection operations, is that it will involve larger volumes and that the reservoir storage pressures will tend to be higher. It is not clear at this point whether these differences, or other considerations, will lead to problems with capital formation that might justify a modification of liability rules.

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December 16, 2008

Rachel Bleshman
Legislative Clerk
House Committee on Energy and Commerce
2322-B Rayburn House Office Building
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CC:
The Honorable Joe Barton, Ranking Member
Committee on Energy and Commerce

The Honorable Gene Green, Chairman
Subcommittee on Environment and Hazardous Materials

The Honorable John Shadegg , Ranking Member
Subcommittee on Environment and Hazardous Materials

Dear Ms. Bleshman:

Enclosed are my responses to Ranking Member Shadegg's questions from the July 24, 2008 Subcommittee on Environment and Hazardous Materials hearing entitled, "Carbon Sequestration: Risks, Opportunities, and Protection of Drinking Water".

Thank you for allowing me the opportunity to further clarify and answer the questions posed. Should you have any further questions, please do not hesitate to contact me at bny@vnf.com or (202) 298 – 1825.

Sincerely,

Ben Yamagata

Ben Yamagata
Executive Director
Coal Utilization Research Council

1. **You suggest that early adopters of sequestration should have the long-term liability of their CO2 storage transferred to and accepted by the government. Will the private sector be willing to engage in CO2 if the liability issues are not addressed?**

Long-term liability for CO_2 injected into a geologic formation for long-term, permanent storage remains a deterrent to CO_2 sequestration. It is presumed, and accepted, that CO_2 sequestration operators/owners will assume the risks associated with storage during the operating phase and for some time post-closure, but they will be unable to take the risk associated with the potential release of sequestered CO_2 in perpetuity. We agree with the recommendation of the IOGCC that for a period of ten years after closure the owner/operator should remain liable.

Also, the Coal Utilization Research Council (CURC) proposes an interim program that is predicated upon an assurance to "first adopters" that the long-term liability of stored CO_2 would be transferred to and accepted by government. This interim program needs to be developed in order for carbon capture and sequestration (CCS) projects to proceed prior to the establishment of a permanent program. Initially, a CCS project would be responsible for the storage of CO_2 during operation of the project and for a period of time (e.g. ten years) after cessation of project activities during which the owner or operator would remain responsible for monitoring and verification post-storage shutdown. Without such assurances through some form of interim program, it is difficult to foresee how any initial CCS project, not knowing the "rules of the road" can proceed.

2. **In testimony before our Energy and Air Quality Subcommittee, the NRDC said that we shouldn't move forward on legislation to help finance CCS deployment projects unless it's part of a comprehensive cap-and-trade bill. Do you agree with that statement, or do you think it's essential for us to move forward on developing carbon capture and sequestration technology before any efforts to cap CO2?**

CURC supports aggressive development of clean coal and carbon capture and storage technologies to ensure that coal will be converted into useful energy as efficiently and cost effectively as possible, with the least impact upon the environment and at a reasonable cost to the consumer. CURC believes that technology and technology innovation are critical to provide options for meeting the challenges to using coal and that CCS will be a primary enabler to reducing greenhouse gas emissions while providing low cost and carbon friendly electricity from coal. Technology also will enable the use of coal in providing needed energy to all sectors of the economy. This technology development must take place <u>now</u>. It can be done separate and apart from enactment of a cap and trade bill. If we are to rely upon CCS to resolve the question of CO_2 from coal then we need to know whether CCS technology is an answer and this need not, indeed cannot, wait for resolution about a cap and trade program.

3. **I find the prospect of possible electricity blackouts in 2009 alarming. Should we move forward on building new coal-fired plants now and worry about trying to retrofit them later? Can we truly afford to halt the construction of coal plants altogether until the technology has matured?**

During 2007, over 30 proposed coal-based power plants were postponed or cancelled. The need for increased electric generation to meet growth and replace older, smaller power plants will undoubtedly arise despite the economic turndown. However, new coal power plants are nearly

impossible to build today because of opposition to new coal-fired power plants. The general response has been to propose the construction of natural gas-based power plants that are less costly to construct, easier and quicker to obtain necessary permits, and emit about one-half the CO_2 of a coal-based power plant. But these generating plants will use a fuel that currently costs much more than coal. Furthermore, while natural gas generation could be built, natural gas supplies will be stressed and we will end up relying upon a high-priced fuel much of which will be imported from abroad. This will only aggravate the economic stresses to consumers, heavy industry, and chemical/fertilizer manufacturing.

Currently, the technologies to capture and sequester CO_2 from coal power plants are under development, but are not ready for widespread adoption. More time and development is needed. In the interim new, highly efficient, environmentally superior coal-based power plants should be constructed to meet growing demand or to replace older, less efficient coal power plants. Consideration might also be given, at that time, to determining when and how such plants – or other agreed upon actions to be taken – can be later retrofitted to reduce CO_2 emissions.